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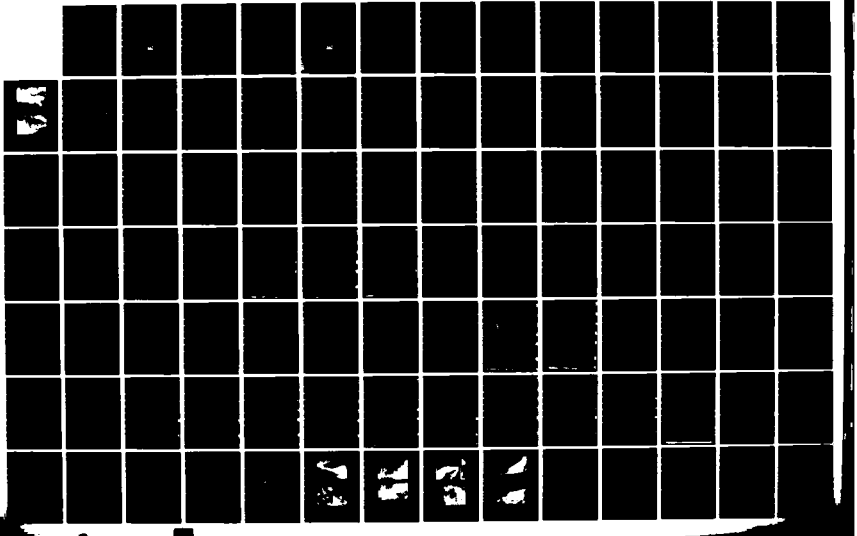
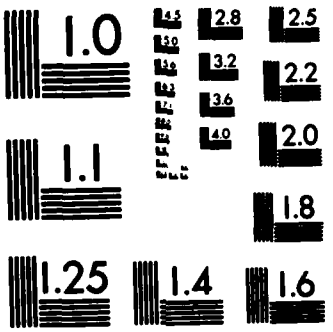
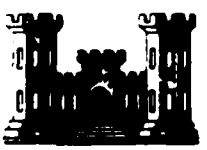




CONNECTICUT COASTAL BASIN
HAMDEN, CONNECTICUT

BUTTERWORTH DAM
CT 00122

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JUNE 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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4. TITLE (and Subtitle): Conn. Coastal Basin Hamden, Conn., Butterworth Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS	5. TYPE OF REPORT & PERIOD COVERED: INSPECTION REPORT
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254	12. REPORT DATE: June 1981 13. NUMBER OF PAGES: 100
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18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Conn. Coastal Basin
Hamden, Conn.
Butterworth Dam

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Butterworth Dam, built in 1963 to impound water for recreational use, is an earth embankment measuring approx. 215 ft. in length and 15 ft. high, with a maximum impoundment capacity of 113 acre-feet. There is a 26 ft. long by 5 ft. deep concrete spillway located within the embankment about 40 ft. from the left abutment. An 18 inch ACCMP low-level outlet extends through the left side of the spillway and discharges to the spillway stilling basin. An 80 ft. long grass lined emergency spillway is located at the right end of the dam.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

SEP 01 1981

NEDED

Honorable William A. O'Neill
Governor of the State of Connecticut
State Capitol
Hartford, Connecticut 06115

Dear Governor O'Neill:

Inclosed is a copy of the Butterworth Dam (CT-00122) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Environmental Protection, and to the owner, State of Connecticut, Department of Environmental Protection, Hartford, CT 06115. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Environmental Protection for your cooperation in this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

Incl
As stated

CONNECTICUT COASTAL BASIN
HAMDEN, CONNECTICUT

BUTTERWORTH DAM
CT 00122

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JUNE 1981

BRIEF ASSESSMENT

PHASE I INSPECTION REPORT

NATIONAL PROGRAM OF INSPECTION OF DAMS

Name of Dam:	BUTTERWORTH DAM
Inventory Number:	CT 00122
State Located:	CONNECTICUT
County Located:	NEW HAVEN
Town Located:	HAMDEN
Stream:	BUTTERWORTH BROOK
Owner:	STATE OF CONNECTICUT
Date of Inspection:	APRIL 29, 1981
Inspection Team:	PETER M. HEYNEN, P.E.
	JAY A. COSTELLO
	MURALI ATLURU, P.E.

The Butterworth Dam, built in 1963 to impound water for recreational use, is an earth embankment measuring approximately 215 feet in length and 15 feet high, with a maximum impoundment capacity of 113 acre-feet. There is a 26 foot long by 5 foot deep concrete spillway located within the embankment about 40 feet from the left abutment. An 18 inch ACCMP low-level outlet extends through the left side of the spillway and discharges to the spillway stilling basin. An 80 foot long grass lined emergency spillway is located at the right end of the dam. This spillway is actually a section of embankment which is 2 feet lower than the top of the dam and has a downstream slope that is flatter than the remaining portion of embankment.

In accordance with the Army Corps of Engineers Guidelines, Butterworth Dam is classified as a significant hazard, small size dam. The test flood range is from the 100 year flood to one-half the Probable Maximum Flood (1/2 PMF). Based on the close proximity of Butterworth Dam to the Mill River and the fairly high location of homes above the river at the impact area, the test flood for this dam is selected as equivalent to the 100 year flood. Peak inflow to the lake at the test flood is 1400 cubic feet per second (cfs) and peak outflow is 1240 cfs with the pond level 0.6 feet below the top of the dam and the headwalls at the principal spillway overtopped by 0.4 feet. The spillway capacities for the principal and emergency spillways with the pond level at the top of the dam are 970 cfs and 665 cfs, respectively. The combined spillway capacity at these conditions is 1635 cfs, which is greater than 100% of the routed test flood outflow. The combined spillway capacity with the pond level to the top of the headwalls (elevation 120.0) is 935 cfs, which is 75% of the routed test flood outflow.

Based upon the visual inspection at the site and past performance of the dam, the project is assessed as being in fair condition. There are items requiring investigation, repair, maintenance and monitoring such as cracking of the concrete training walls at the principal spillway, brush and erosion on the slopes, the lack of proper riprap protection on the upstream slope and a wet area at the toe of the dam.

It is recommended that the owner initiate further studies to be performed by a registered professional engineer. These studies should include; 1) investigation into the cause of, and procedures for repair of, cracks in the concrete spillway training and wing walls, 2) procedures for raising the low area at the principal spillway headwalls to the top of the dam, elevation 121.0, and providing adequate protective cover 3) further inspection when there is no flow over the principal spillway to determine the condition of the low-level outlet, the downstream face of the spillway, and the drain holes at the base of the spillway structure, 4) regrading the top and side slopes of the embankment and improving the riprap protection on the upstream slope between the expected high and low water elevations, 5) investigation to determine the origin and significance of the wet area at the toe of the dam, 6) investigation of the transition area from emergency spillway to downstream slope at the left side of the emergency spillway to insure that flows from the emergency spillway will not discharge along the downstream slope and erode the embankment. Recommended corrective procedures addressing these items, and others presented in Section 7, should be established by the engineer and implemented by the owner.

The above items and further remedial measures presented in Section 7.3, should be instituted within one (1) year of the owners' receipt of this report.

Peter M. Heynen, P.E.
Chief Geotechnical Engineer
Cahn Engineers, Inc.

STATE OF CONNECTICUT
PETER M. HEYNEN
PROFESSIONAL ENGINEER

C. Michael Horton, P.E.
Chief Engineer
Cahn Engineers, Inc.

STATE OF CONNECTICUT
CLARENCE M. HORTON
PROFESSIONAL ENGINEER

This Phase I Inspection Report on Butterworth Dam (CT 00122) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH W. FINEGAN, JR., CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspection. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam would necessarily represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions there of. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as neccessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

The information contained in this report is based on the limited investigation described above and is not warranted to indicate the actual condition of the dam. The integrity of the dam can only be determined by a means of a monitoring program and/or a detailed physical investigation. The accuracy of available data is assumed where not in obvious conflict with facts observable during the visual inspection.

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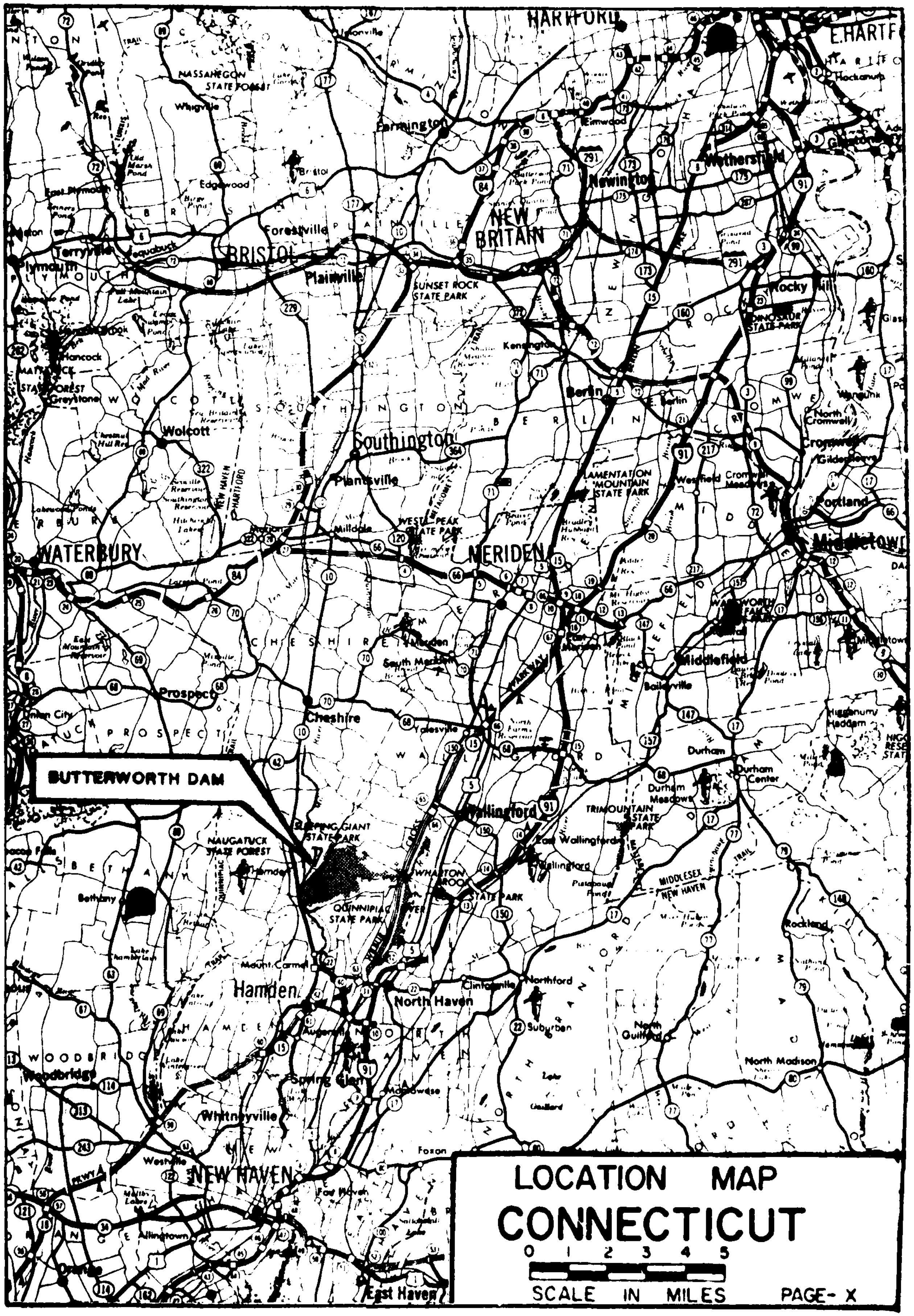
View from right side of pond

View from left side of pond



BUTTERWORTH DAM
HARTFORD
NEW BRITAIN
BRISTOL
WATERBURY
MERIDEN
Southington
Cheshire
Wallingford
Hamden
NEW HAVEN
North Haven
Wethersfield
Newington
Plainville
Farmington
Berlin
Middletown
Portland
Cromwell
Middlefield
Durham
Wolcott
Prospect
Bethany
Woodbridge
Plantsville
SLEEPING GIANT STATE PARK
NAUGATUCK STATE FOREST
East Haven
LOCATION MAP
CONNECTICUT
0 1 2 3 4 5
SCALE IN MILES
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PHASE I INSPECTION REPORT

BUTTERWORTH DAM

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority - Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Cahn Engineers, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Authorization and notice to proceed were issued to Cahn Engineers, Inc. under a letter of April 3, 1981 from William E. Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW 33-80-C-0052 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection Program - The purposes of the program are to:

1. Perform technical inspection and evaluation of non-federal dams to identify conditions requiring correction in a timely manner by non-federal interests.

2. Encourage and prepare the States to quickly initiate effective dam inspection programs for non-federal dam.

3. To update, verify and complete the National Inventory of Dams.

c. Scope of Inspection Program - The scope of this Phase I inspection report includes:

1. Gathering, reviewing and presenting all available data as can be obtained from the owners, previous owners, the state and other associated parties.

2. A field inspection of the facility detailing the visual condition of the dam, embankments and appurtenant structures.

3. Computations concerning the hydraulics and hydrology of the facility and its relationship to the calculated flood through the existing spillway.

4. An assessment of the condition of the facility and corrective measures required.

It should be noted that this report passes judgment only on those factors of safety and stability which can be determined by a visual surface examination. The inspection is to identify those visually apparent features of the dam which evidence the need for corrective action and/or further study and investigation.

1.2 DESCRIPTION OF PROJECT

a. Location - The dam is located on Butterworth Brook about 700 feet above the confluence with the Mill River (Connecticut Coastal Basin) in a rural area of the town of Hamden, County of New Haven, State of Connecticut. The dam is shown on the Mount Carmel USGS Quandrangle Map, having coordinates latitute N41° 26.2' and longitude W72° 54.0'.

b. Description of Dam and Appurtenances - The dam is approximately 215 feet long and 15 feet high from the stilling basin sill to the top of the embankment. At elevation 121.0, the top of the embankment is 6 feet above the principal spillway crest and measures 10 feet wide, except at the right end where it widens to 20 feet and drops 2 feet in elevation for the emergency spillway. The upstream slope of the embankment is inclined at 3 horizontal to 1 vertical and the downstream slope is inclined at about 2 horizontal to 1 vertical, except at the emergency spillway, where it is 4 horizontal to 1 vertical. Exact dimensions of the cutoff trench are unknown, however the construction specifications call for a minimum width of 4 feet at the base, a minimum depth of 3 feet and side slopes no greater than 1 horizontal to 1 vertical.

The principal spillway is a 26 foot long concrete structure with a flat approach channel riprapped to the spillway crest (elevation 115.0), and a 10 foot vertical drop to a stilling basin on the downstream side (See Sheet B-1). A 9 inch high by 1/4 inch thick plate of sheet metal has been placed across the spillway, raising the point of overflow to elevation 115.8. Concrete training and head walls, located at each end of the spillway, have a maximum elevation of 120.0. The headwalls extend out parallel to the axis of the dam for about 15 feet, where the embankment slopes up 1 foot to elevation 121.0 (See Sheet B-1).

A grass-lined swale, which forms the emergency spillway at the right end of the dam, measures 80 feet long and 2 feet deep with a crest elevation of 119.0. In order to accomodate emergency spillway flows, the width at the top of the embankment was increased to 20 feet in this area and the downstream slope was flattened to 4 horizontal to 1 vertical. Flows from this spillway are discharged to a flat swampy area at the toe of the dam before flowing to Butterworth Brook.

An 18 inch asphalt coated corrugated metal pipe (ACCMP) is located at the left end of the principal spillway and discharges into the stilling basin. This pipe is the low-level outlet and has intake and outlet elevations of 108.0 and 107.0, respectively. According to existing plans, an 18 inch slide gate is located on the upstream side of the principal spillway and can be operated by the valve stem, about 2 feet from the left spillway training wall.

c. Size Classification - SMALL - The dam impounds 113 acre-feet of water with the pond level to the top of the dam and the embankment measures about 15 feet in height. According to the U.S. Army Corps of Engineers' Recommended Guidelines, a dam with a maximum storage capacity of at least 50 acre-feet but less than 1000 acre-feet is classified as small in size.

d. Hazard Classification - SIGNIFICANT - A potential for economic damage as well as possible loss of a few lives exists at the Sleeping Giant Golf Course, which is actively used and located on the Mill River about 2300 feet below the dam. If the dam were breached, flood waters would flow into the Mill River, which runs through the golf course. At this impact area, the Mill River is expected to rise from a depth of 4.6 feet to a depth of 7.1 feet, resulting in a water velocity of 4.5 feet per second and inundation of portions of the golf course. In addition, the bridges at River Road and Tuttle Avenue would be impacted upon failure of the dam, but no residential or industrial structures are expected to experience major flooding as a result of failure of Butterworth Dam.

e. Ownership - State of Connecticut
Department of Environmental Protection
Mr. Joe Voboril, Property Management
(203)-566-4419
Mr. Richard Misca, Supervisor Sleeping Giant
State Park (203)-789-7498

f. Operator - Mr. Frank Butterworth (203)-248-3213

Mr. Butterworth was the original owner of the dam. The State of Connecticut purchased the property in December 1969, but Mr. Butterworth has retained lifetime usage of the pond area. The value stem is in Mr. Butterworth's possession, however Mr. Butterworth is not responsible for maintenance of the dam.

g. Purpose of Dam - The dam is used strictly for recreational purposes and wildlife habitat.

h. Design and Construction History - The dam was designed in 1961 by the U.S. Department of Agriculture, Soil Conservation Service. After some changes to increase emergency spillway capacity, the design was approved by the Connecticut Water Resources Commission. Construction was completed in 1963, inspected and a certificate of Approval issued by the Water Resources Commission.

1.3 PERTINENT DATA

a. Drainage Area - The drainage area is 2.3 square miles of rolling to mountainous, sparsely developed and wooded land located in the Connecticut Coastal Basin. A considerable portion of the watershed lies on the northern slope of Mount Carmel.

b. Discharge at Damsite - Normal discharge is over the principal spillway and through the low-level outlet. The elevations listed below are N.G.V.D. based on existing design plans.

1. Outlet Works (conduits):

18 inch ACCMP low-level outlet at u/s invert el. 108.0:	52 cfs (w.s. @ top of dam)
2. Maximum flood at Damsite:	Unknown
3. Principal Spillway capacity @ top of headwall el. 120.0:	706 cfs
4. Principal Spillway capacity @ test flood el. 120.4:	810 cfs
5. Principal Spillway capacity @ top of dam el. 121.0:	970 cfs
6. Emergency Spillway capacity @ test flood el. 120.4:	380 cfs
7. Emergency spillway capacity @ top of dam el. 121.0:	665 cfs
8. Total spillway capacity @ top of headwall el. 120.0:	935 cfs
9. Total spillway capacity @ test flood el. 120.4:	1190 cfs
10. Total spillway capacity @ top of dam el. 121.0:	1635 cfs
11. Total project discharge @ test flood el. 120.4:	1240 cfs
12. Total project discharge @ top of dam el. 121.0:	1687 cfs

c. Elevations - (All elevations are N.G.V.D. based on field investigations and existing plans)

1. Streambed at toe of dam:	106.0
2. Bottom of cutoff:	103.0
3. Maximum tailwater:	Unknown
4. Normal pool:	115.8
5. Full flood control pool:	N/A
6. Principal spillway crest:	115.0 (concrete) 115.8 (sheetmetal flash-board)

7. Emergency spillway crest	119.0
8. Design surcharge (original design):	119.5
9. Top of spillway headwalls:	120.0
10. Top of dam:	121.0
11. Test flood surcharge:	120.4
d. Reservoir (Length in feet)	
1. Normal pool:	1750 feet
2. Flood Control pool:	N/A
3. Spillway crest pool:	1750 feet
4. Top of dam pool:	2100 feet
5. Test flood pool:	2000 feet
e. Storage (Acre-feet)	
1. Normal pool:	33 acre-feet
2. Flood control pool:	N/A
3. Spillway crest pool:	33 acre-feet (El. 115.8)
4. Top of dam pool:	113 acre-feet
5. Test flood pool:	100 acre-feet
f. Reservoir Surface (Acres)	
1. Normal pool:	10 acres
2. Flood control pool:	N/A
3. Spillway crest pool:	10 acres (El. 115.8)
4. Top of dam pool:	20 acres
5. Test flood pool:	18 acres
g. Dam	
1. Type:	Earth
2. Length:	215 feet
3. Height:	18 (Structural) 15 (Hydraulic)
4. Top width:	10 feet

5.	Side slopes:	3H to 1V (u/s) 2H to 1V (d/s) 4H to 1V (d/s channel emergency spillway)
6.	Zoning:	N/A
7.	Impervious Core:	N/A
8.	Cutoff:	Trench to bedrock or hardpan
9.	Grout curtain:	N/A
10.	Other:	N/A

h. Diversion and Regulating Tunnel - N/A

i. Spillway

Principal

1.	Type:	Concrete
2.	Length of weir:	26 feet
3.	Crest elevation:	115 (concrete) 115.8 (flashboard)
4.	Gates:	N/A
5.	Upstream Channel:	Flat, riprap
6.	Downstream Channel:	Natural streambed
7.	General:	10 foot vertical drop from spillway crest to stilling basin. Stilling basin sill elevation = 106.0. Top of headwalls = elevation 120.0

Emergency

1.	Type:	Grassed swale at right end of embankment
2.	Length of weir:	80 feet
3.	Crest elevation:	119.0
4.	Gates:	N/A
5.	Upstream Channel:	u/s slope of embankment, 3H to 1V

6. Downstream channel:	d/s slope of embankment, 4H to 1V
7. General:	N/A

j. Regulating Outlet

1. Invert:	108.0 (u/s) 107.0 (d/s)
2. Size:	18 inch
3. Description:	ACCMP
4. Control Mechanism:	18 inch slide gate with valve stem @ left u/s side of principal spillway
5. Other:	Discharges to principal spillway stilling basin

SECTION 2: ENGINEERING DATA

2.1 DESIGN

The available plans are a set of 7 sheets prepared by the U.S. Department of Agriculture, Soil Conservation Service. These include plan view, pond area, cross sections, profile and structural details for the principal spillway. Also available are a preliminary geologic investigation of the dam site and hydraulic/-hydrologic computations for the principal spillway design.

2.2 CONSTRUCTION

The only data available for the original construction of the dam is a set of construction specifications dated January 1960.

2.3 OPERATION

There are no lake level readings taken at the dam or any formal operation records in existence.

2.4 EVALUATION

a. Availability - Existing data was provided by the State of Connecticut, Department of Environmental Protection. The owner made the project available for visual inspection.

b. Adequacy - Since design drawings and hydraulic computations are available, the assessment of the project is based on a review of this data, performance history, visual inspection, hydraulic computations and hydrologic judgements.

c. Validity - A comparison of record data and visual observations indicate that the dam was probably constructed as designed. A sheet metal flashboard was constructed across the principal spillway sometime after initial construction. No other discrepancies were observed in the record data.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General - Based on the visual inspection performed on April 29, 1981, the condition of the dam is assessed as fair. The inspection revealed items requiring repair, maintenance, and monitoring. The lake level was at about 116.0 with 2 to 3 inches of water over the spillway at the time of the inspection.

b. Dam

Top of Dam - The top of the dam is slightly irregular with small trees and brush growing along the entire length of the dam (Photos 1, 2 and overviews). The top of the embankment drops 2 feet and doubles in width at the right end for the emergency spillway. At the principal spillway, the top of the dam drops 1 foot to the top of the spillway headwall, about 15 feet from the right end of the spillway. In this area the earth fill does not reach the top of the headwalls, and the grass cover has been eroded by trespassing and runoff (Photo 5).

Upstream Slope - The upstream slope has some minor sloughing and erosion occuring at the waterline (Photo 1). The riprap is very sparse and does not provide adequate protection here. There is some erosion of the grass cover on this slope at the central portion and left end of the dam. Brush and small trees cover the slope (Overview Photo).

Downstream Slope - The downstream slope is overgrown with brush and small trees up to 2 inches in diameter (Photo 2 and Overview). The grass cover has been eroded at both sides of the principal spillway by foot traffic and runoff (Photo 6). The slope flattens at the right end of the dam to accomodate flows from the emergency spillway. The toe of the dam is wet and soft but no flows could be observed which would appear to be embankment seepage. The entire area at the toe of the dam is swampy, with vegetation indigenous to low wet areas, and therefore is probably not a concern. Because of the thick trees and brush, the toe and downstream slope were difficult to inspect.

Spillway

Principal - There are stones piled up in the discharge channel just downstream of the stilling basin sill (Photo 4). These stones are increasing the tailwater depth above the weep holes in the training walls (Sheet B-1). Both wingwalls have many hairline cracks running through them. A large crack with spalling and brown staining, and measuring 3 feet long by 2 inches deep, is located about 3.5 feet above the base of the right training wall (Photo 7). There is also a 3+ inch diameter hole at the downstream end of this wall about 2 feet above the base of the wall (Photo 8). A 9 inch high by ¼ inch thick sheet metal plate has been constructed across the spillway crest to raise the lake level (Photo 3). There

were some sticks and small logs in the approach and discharge channels at the time of the inspection. The downstream side of the spillway could not be inspected because of flow over the spillway weir.

Emergency - This spillway is completely overgrown with trees and brush and was very hard to inspect or photograph. The exact shape and slope of the spillway could not be determined, but it appears to have been built fairly close to design dimensions.

c. Appurtenant Structures - The outlet for the 18 inch low-level outlet pipe could not be observed because there was flow over the spillway and the pipe outlets on the downstream side of the spillway weir. The outlet was closed and not operated at the time of the inspection, but is reported by Mr. Butterworth to be operable.

d. Reservoir Area - The area surrounding the pond is sparsely developed, wooded and rolling to mountainous.

e. Downstream Channel - The downstream channel runs in the natural streambed of Butterworth Brook to the Mill River approximately 700 feet downstream. The brook is fairly clear of debris and overhanging trees.

3.2 EVALUATION

Based upon the visual inspection, the dam is assessed as being in fair condition. The following features which could influence the future condition and/or stability of the dam were identified.

1. The 1.0 foot difference in elevation between the top of the spillway headwalls and the top of the dam will provide an area of overtopping at the headwalls during the test flood conditions, possibly eroding the embankment in this area.

2. Cracking of the concrete training walls and wingwalls at the principal spillway could lead to eventual failure of the spillway structure.

3. Stones piled in the spillway channel are resulting in a higher tailwater than indicated on design drawings. This higher tailwater restricts monitoring of structural drain holes.

4. Erosion of the grass cover on the downstream slope, upstream slope and top of the dam could cause areas of severe erosion and possibly lead to failure of the earth embankment, should these portions of the dam be overtopped. The erosion at the top of the dam and downstream slope near the principal spillway headwalls (Photos 5 and 6) are of more concern because this area is the first point of overtopping, should the pond level exceed elevation 120.0.

5. Trees and brush on the dam embankment, if allowed to grow, could provide seepage paths along root systems or produce depressions which may be critical to dam stability if uprooted. Growth in the emergency spillway will inhibit flow, thereby reducing the capacity for which the spillway was designed.

6. The lack of proper riprap protection on the upstream slope and near the wingwalls at the principal spillway discharge channel will lead to erosion of these areas.

SECTION 4: OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 OPERATIONAL PROCEDURES

a. General - No formal program of operation is in effect. No lake level or discharge readings are taken at the dam.

b. Description of any Warning System in Effect - No formal warning system is in effect.

4.2 MAINTENANCE PROCEDURES

a. General - There is no formal program of maintenance or inspection at the dam.

b. Operating Facilities - No formal program for maintenance of the operating facilities is in effect.

4.3 EVALUATION

A formal program of operation and maintenance procedures should be implemented, including documentation of lake levels for future reference. Also, a formal warning system should be developed within the time frame indicated in Section 7.1(c). Remedial operation and maintenance recommendations are presented in Section 7.

SECTION 5: EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 GENERAL

The watershed for Butterworth Dam consists of 2.34 square miles of rolling to mountainous terrain, some of which is developed for residential and agricultural uses. The remainder of the watershed is mostly wooded. A considerable portion of the watershed lies along the northern slope of Mt. Carmel and consists of extremely steep and rocky terrain. The watershed elevations range from 116 to 708 feet NGVD.

The maximum impoundment to the top of the dam (El. 121.0 NGVD) is estimated to be 113 acre-feet and estimated storage below the main spillway crest is 33 Acre-feet.

The dam is classified as small in size having a significant hazard potential.

5.2 DESIGN DATA

Design drawings, revised November 30, 1962, and some hydraulic/hydrologic design data are available. The design high water level is estimated to be 119.5 NGVD and the design is based on a storm of 100 year frequency.

5.3 EXPERIENCE DATA

No information on any problem situations arising at the dam was found. The maximum previous discharge at the dam is unknown.

5.4 TEST FLOOD ANALYSIS

Based upon the Army Corps of Engineer's "Preliminary Guidance for Estimating Maximum Probable Discharges", dated March 1978, the watershed classification (rolling to mountainous) and a drainage area of 2.34 square miles; a PMF of 5,300 CFS, or 2250 cfs per square mile, is estimated at the dam site. The dam is classified as a small size, significant hazard dam. Therefore, the test flood range to be considered is from 100 year to ½ PMF. Based upon the involved downstream risk potential, a 100 year test flood is selected. In Connecticut, a 100 year flood is estimated to result from approximately 5 inches of runoff, which is approximately equivalent to 5/19 of the PMF inflow.

The peak inflow to the pond at the selected test flood is 1,400 CFS and the peak outflow is estimated to be 1,240 CFS with maximum pool elevation at 120.4 NGVD. Since the top of the embankment elevation is 121.0 NGVD, the embankment is not overtopped for the test flood condition, however the top of the spillway headwalls will be overtopped by 0.4 feet. The principal spillway capacity with pool at top of dam (el. 121.0) and elevation 120.0 (top of

headwalls) is 970 cfs and 706 cfs, respectively. The emergency spillway capacity at top of dam and top of headwall elevations is 665 cfs and 229 cfs. Combined spillway capacity with the pool at top of dam is 1635 cfs, which is greater than 100% of the routed test flood outflow. Combined spillway capacity at elevation 120.0 is 935 cfs, which is 75% of the routed test flood outflow.

5.5 DAM FAILURE ANALYSIS

The southeastern portion of Sleeping Giant Golf Course is located on the Mill River approximately 2300 feet below the dam and is designated as the impact area (Sheet D-1). This golf course is divided in two parts by the river and has several fairway crossings. In addition to this impact area, the bridges at River Road and Tuttle Avenue would also be impacted upon failure of the dam. No residential or industrial buildings are expected to be impacted upon failure of Butterworth Dam.

Utilizing the Corps of Engineers April 1978 "Rule of Thumb Guidance for Estimating Downstream Failure Hydrographs", the peak failure outflow due to dam breach is estimated to be 7300 CFS, with an estimated flood depth of 6.6 feet immediately downstream of the dam. The breach width is estimated to be 68 feet, which is assumed to include the main spillway and outlet pipe. The flood routing was performed for peak failure outflow with pool at top of dam, elevation 121.0. The pre-failure flow at the impact area before failure is estimated to be 1250 cfs causing a depth of 4.6 feet in the stream. After failure, the flood stage is estimated to increase to a depth 7.1 feet, resulting in a flow of 3940 cfs.

The rapid 2.5 foot rise in the Mill River at the impact area will raise the flood stage to elevation 105.3 NGVD, which will increase the stream velocity to more than 4 fps and inundate portions of the golf course and fairway crossings by as much as 5 feet. The golf course is actively used and therefore represents a potential for extensive economic loss as well as loss of life due to dam failure. In addition, the bridges on River Road and Tuttle Avenue have inadequate capacities and represent potential damage (See Appendix D).

Based upon the hydraulic/hydrologic analysis (Appendix D) and the potential for economic loss as well as loss of lives, the dam has a significant hazard classification.

SECTION 6: EVALUATION OF STRUCTURAL STABILITY

6.1 VISUAL INSPECTION

The dam is a 215 foot long earth embankment with a cutoff trench excavated to bedrock or hardpan, a concrete principal spillway and a grass lined emergency spillway. The embankment has a structural height of 18 feet, a hydraulic height of 15 feet and a top width of 10 feet, except at the right end, where it widens to 20 feet for the 80 foot long emergency spillway. The side slopes of the embankment are 3 horizontal to 1 vertical upstream, 2 horizontal to 1 vertical downstream and 4 horizontal to 1 vertical at the emergency spillway. The principal spillway is 26 feet long, has 5 foot high training walls and a 15 foot long headwall at each end which is 1 foot lower than the top of the embankment (See Sheet B-1). The top of the dam is at elevation 121.0, the emergency spillway crest is elevation 119.0, the principal spillway crest is elevation 115.8 (a 9 inch high flashboard has been added) and the top of the headwalls are at elevation 120.0. The low-level outlet is an 18 inch ACCMP located at the left end of the spillway. No evidence of toe drains, piezometers, or other seepage control or monitoring devices were found at the dam.

The visual inspection revealed cracking and spalling of the concrete training walls and wingwalls at the principal spillway, minor erosion and sloughing of the upstream slope, erosion of the grass cover on the top of the dam and downstream slope at the spillway headwalls, and a thick growth of small trees and brush on the embankment and in the emergency spillway.

No seepage was observed on the downstream slope or at the toe of the dam, although the toe is wet and swampy. Except for some minor sloughing of the upstream slope, the embankment appears to be stable. The concrete walls at the spillway structure are cracking and should be investigated to determine the cause. The headwalls at the spillway are 1 foot lower than the top of the dam and will be overtopped by 0.4 feet at the test flood conditions. With the erosion of the embankment in this area, flows over these headwalls may present further erosion problems. The emergency spillway will not function properly unless the brush is cleared. Flows from the emergency spillway may discharge along the downstream slope, causing erosion in this area. Based upon these conclusions and the hydraulic/hydrologic analysis, the dam is judged to be in fair condition. Recommendations for the above items, as well as others outlined in Section 3, are presented in Section 7.

6.2 DESIGN AND CONSTRUCTION DATA

The dam appears to have been built according to design plans. Construction specifications are available and presented in Appendix B. There is no evidence of problems or unusual circumstances arising during construction of the dam or filling of the pond.

6.3 POST CONSTRUCTION CHANGES

The only known change has been the addition of 9 inch high by 1/4 inch thick sheet metal across the principal spillway, raising the crest elevation from 115.0 to 115.8.

6.4 SEISMIC STABILITY

The dam is in Seismic Zone 1 and according to the U.S. Army Corps of Engineers' Recommended Guidelines, need not be evaluated for seismic stability.

SECTION 7: ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Condition - Based upon the visual inspection of the site and past performance, the dam is judged to be in fair condition. There are items requiring repair and maintenance. These are presented in Section 7.2 and 7.3.

Peak inflow to Butterworth Pond is 1400 cfs and peak outflow is 1240 cfs with the dam maintaining 0.6 feet of freeboard and principal spillway headwalls overtopped by 0.4 feet. The principal spillway and emergency spillway capacities are 970 cfs and 665 cfs respectively, with the pond to the top of the dam (el. 121.0). The total spillway capacity with the water level at elevation 120.0 is 935 cfs, which is 75% of the routed test flood outflow. The combined spillway capacity at top of dam is 1635 cfs, which is greater than 100% of the routed test flood outflow.

b. Adequacy of Information - Design drawings and spillway design computations are available and were reviewed during assessment of the structure. However the final assessment is based on the visual inspection, history of the dam, hydraulic/hydrologic computations and sound engineering judgement.

c. Urgency - It is recommended that corrective measures addressing the items presented in Section 7.2 and 7.3 be implemented within 1 (one) year of the owner's receipt of this report.

7.2 RECOMMENDATIONS

It is recommended that the owner initiate further studies to be performed by a registered professional engineer qualified in dam design and inspection, pertaining to the following items. Recommended corrective procedures should be established by the engineer and implemented by the owner.

1. The spillway structure should be inspected when there is no flow over the spillway. Cracks in the concrete training walls and wingwalls should be investigated to determine the cause of these cracks and possible corrective procedures.

2. The present tailwater depth should be investigated to determine if the stones increasing the tailwater depth at the spillway stilling basin should be removed, or if this tailwater depth is needed for energy dissipation. The spillway discharge channel should be cleared of debris and the banks of the channel riprapped at the ends of the wingwalls.

3. Trees and their root systems and brush should be removed from the embankment slopes, emergency spillway and within 15 feet from the toe of the dam. The slopes and top of dam should be regraded and the protective cover re-established. Particular care should be taken to retain the design shape at the emergency spillway.

4. The upstream slope should be regraded to eliminate sloughing, with riprap placed between the expected high and low water elevations.

5. The low areas on each side of the principal spillway should be raised to elevation 121.0. Fill placed on the upstream and downstream slopes should be properly protected.

6. The area of transition from emergency spillway to downstream slope at the left side of the emergency spillway should be investigated to insure that flows from the emergency spillway will not discharge along the downstream slope and erode the embankment.

7. After trees and brush have been removed from the downstream slope and toe of the dam, the embankment should be inspected for seepage and to insure that the swampy area at the toe of the dam is not seepage related.

7.3 REMEDIAL MEASURES

The following operation and maintenance procedures should be undertaken by the owner and continued on a regular basis.

1. A formal program of operation and maintenance procedures should be instituted and fully documented to provide accurate records for future reference. A program for monthly inspection by the owner or owner representative should be developed and include proper documentation.

2. A comprehensive program of inspection by a registered professional engineer qualified in dam design and inspection should be instituted on an annual basis.

3. The owner should develop and implement a downstream warning system in case of emergencies at the dam.

4. Debris should be removed from the spillway approach and discharge channels, and the brush cut from the embankment and toe on a regular basis.

7.4 ALTERNATIVES

The study has identified no practical alternatives to the above recommendations.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Butterworth Dam

DATE: April 29, 1981

TIME: 9:00AM - 11:00AM

WEATHER: Cloudy, 65°F

W.S. ELEV. 115.9 U.S. 108.0 DN.S

PARTY:	INITIALS:	DISCIPLINE:
1. Peter M. Heynen	PMH	Cann-Geotech.
2. Murali Atluru	MA	DTC-H/H
3. Joy A. Costello	JAC	Cann-Geotech.
4.		
5.		
6.		

PROJECT FEATURE	INSPECTED BY	REMARKS
1. Embankment	PMH, MA, JAC	A-2
2. Principal Spillway	PMH, MA, JAC	A-3
3. Emergency Spillway	PMH, MA, JAC	A-4
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

PERIODIC INSPECTION CHECK LIST

PROJECT Butterworth Dam DATE April 29, 1981

PROJECT FEATURE Earth Embankment BY PMH, JAC, MA

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	121.0
Current Pool Elevation	115.9
Maximum Impoundment to Date	Unknown
Surface Cracks	None Visible
Pavement Condition	N/A
Movement or Settlement of Crest	None Observed
Lateral Movement	
Vertical Alignment	Appears Good
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None Observed
Trespassing on Slopes	Top of dam and d/s slope
Sloughing or Erosion of Slopes or Abutments	Minor sloughing u/s slope. Erosion at trespassing either side of principal spillway on d/s slope.
Rock Slope Protection-Riprap Failures	Very little riprap @ waterline
Unusual Movement or Cracking at or Near Toes	None observed
Unusual Embankment or Downstream Seepage	Wet area at toe of emergency spillway
Piping or Boils	None Observed
Foundation Drainage Features	
Toe Drains	
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

PROJECT Eastern Dam DATE April 29, 1981

PROJECT FEATURE Principal Spillway BY PMH, MA, JAC

AREA EVALUATED	CONDITION
OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	Concrete w/ crest elevation at 115.9 and sloping north sides above elevation 12.0.
a) Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channel	
Floor of Approach Channel	Flat, riprap protection, small logs and branches in channel
b) Weir and Training Walls	
General Condition of Concrete	Fair - hairline cracks in wingwalls, larger cracks in left training wall up to 2" deep X 36" long. Brown staining below cracks. No visible rebars.
Rust or Staining	
Spalling	Some spalling at corner of wingwall and training wall.
Any Visible Reinforcing	
Any Seepage or Efflorescence	Difficult to observe - wall is wet
Drain Holes	Below tailwater - not observed
c) Discharge Channel	Concrete stilling basin
General Condition	Appears good - under water & hard to observe
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	d/s channel has some
Floor of Channel	Natural streambed
Other Obstructions	Some wood & debris

PERIODIC INSPECTION CHECK LIST

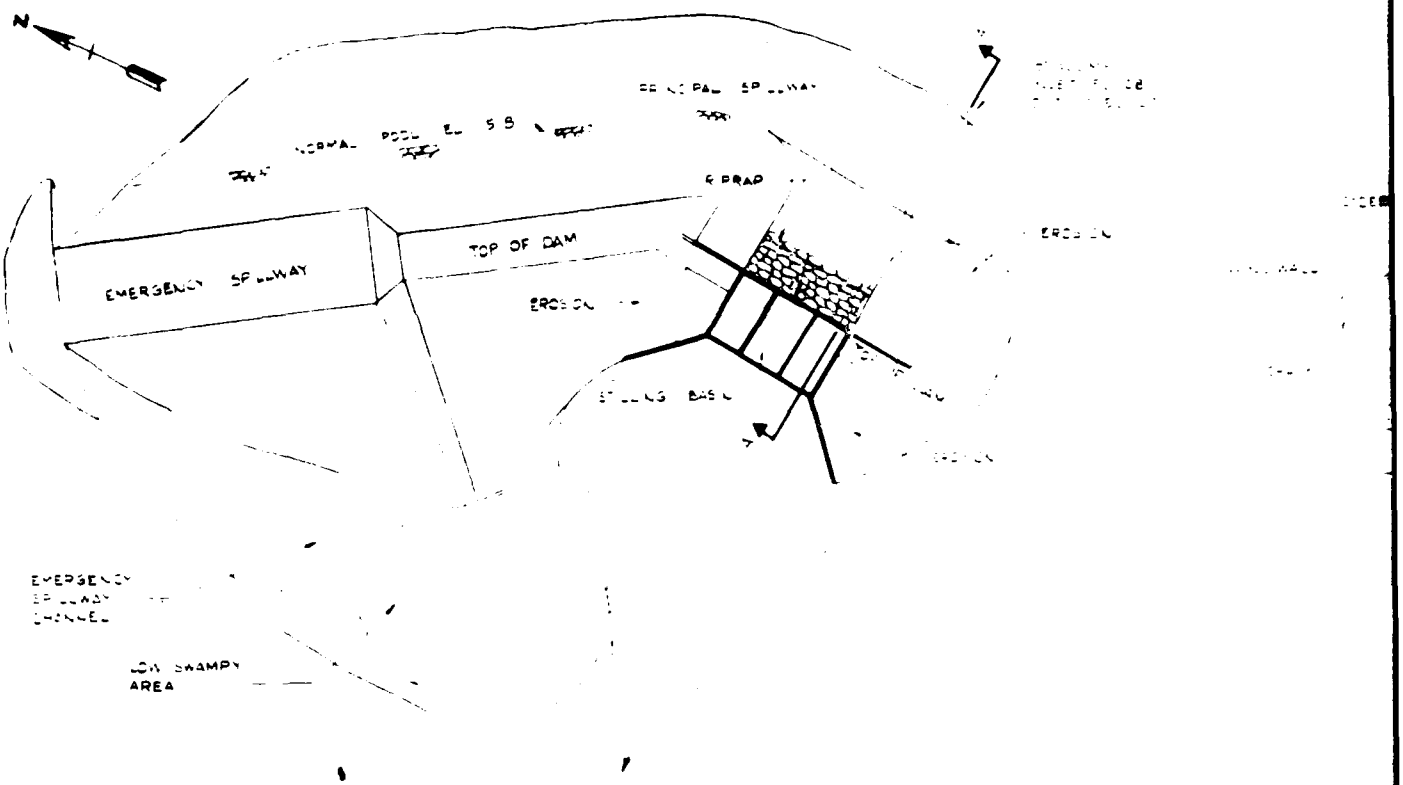
PROJECT Butler Dam DATE April 29, '81

PROJECT FEATURE Emergency Spillway BY EMH, MAJAC

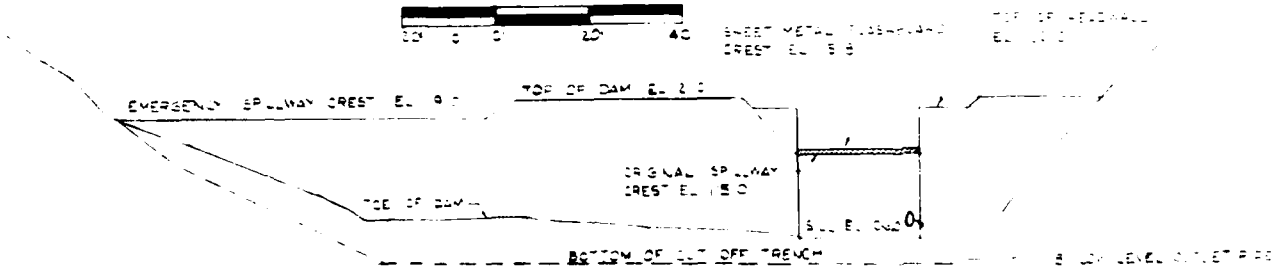
AREA EVALUATED		CONDITION
OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS		Grass lined channel at right end of embankment. Length is 80'; Crest elevation is 1119.0.
a) Approach Channel		
General Condition		Poor
Loose Rock Overhanging Channel		N/A
Trees Overhanging Channel		Brush and trees growing in channel on top of dam & in sloping discharge channel d/s slope of dam.
Floor of Approach Channel		
b) Weir and Training Walls		
General Condition of Concrete		N/A
Rust or Staining		
Spalling		
Any Visible Reinforcing		
Any Seepage or Efflorescence		
Drain Holes		
c) Discharge Channel		
General Condition		Poor
Loose Rock Overhanging Channel		N/A
Trees Overhanging Channel		Trees & brush in channel on d/s slope and toe of dam embankment to principal spillway discharge channel.
Floor of Channel		
Other Obstructions		

APPENDIX B

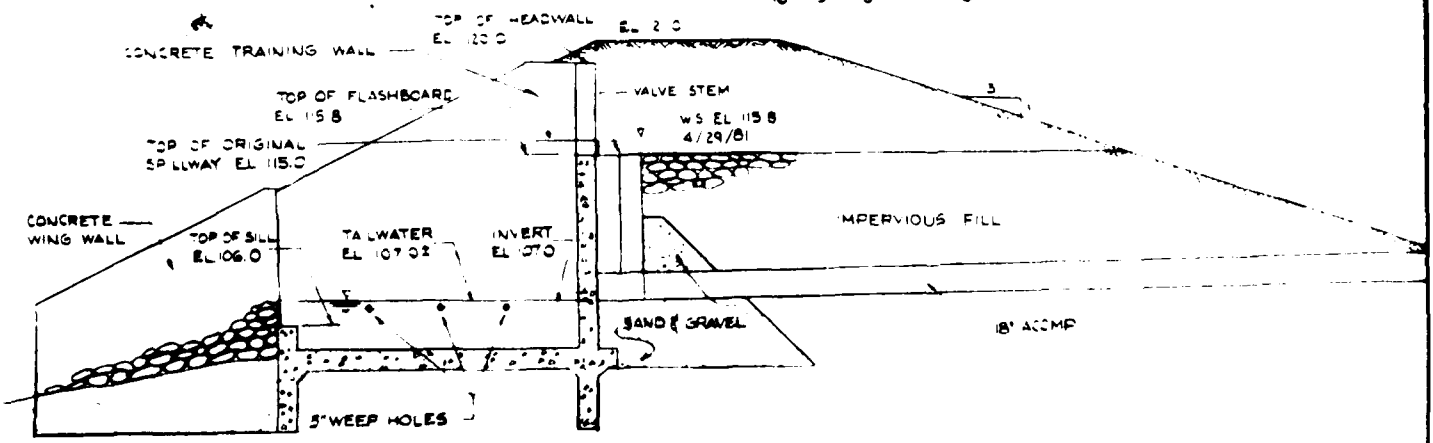
ENGINEERING DATA AND CORRESPONDENCE



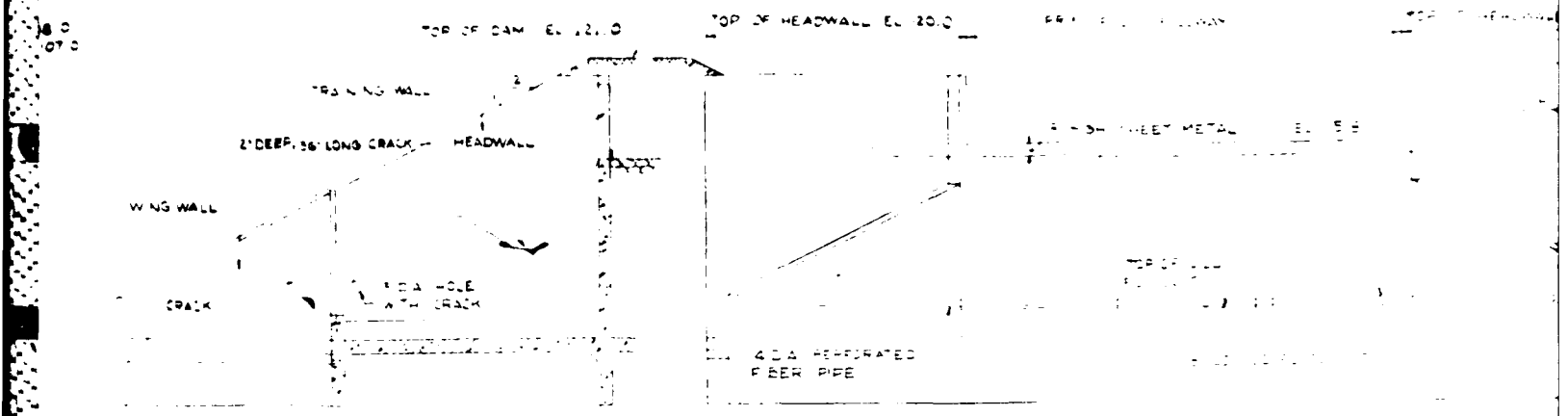
PLAN VIEW



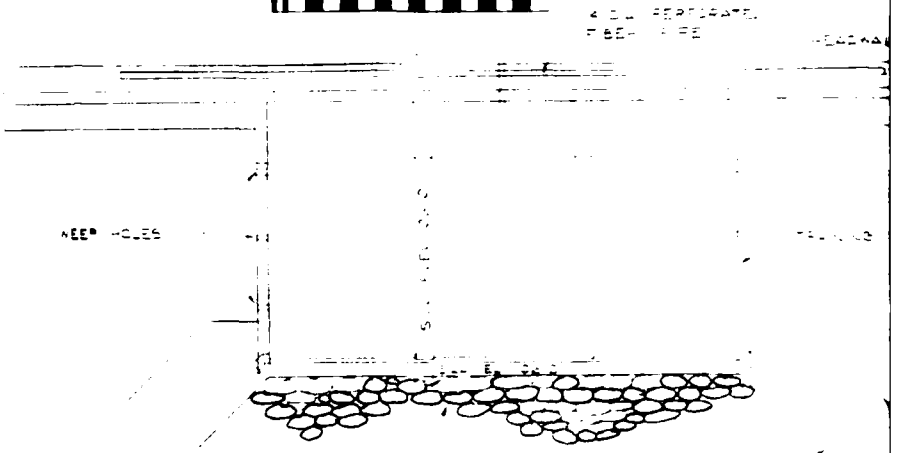
ELEVATION



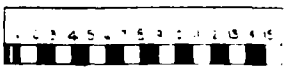
SECTION A-A

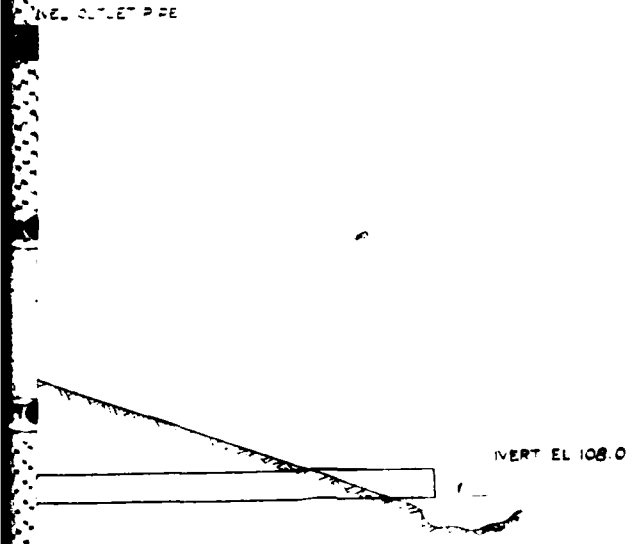


SPILLWAY ELEVATION



SPILLWAY PLAN





NOTES:

1. THIS DRAWING IS COMPILED FROM EXISTING PLANS BY THE U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE REVISED 1962 AND A CAHN ENGINEERS FIELD INSPECTION ON APRIL 29 1981
2. ALL ELEVATIONS ARE N.G.V.D. BASED ON EXISTING PLANS.

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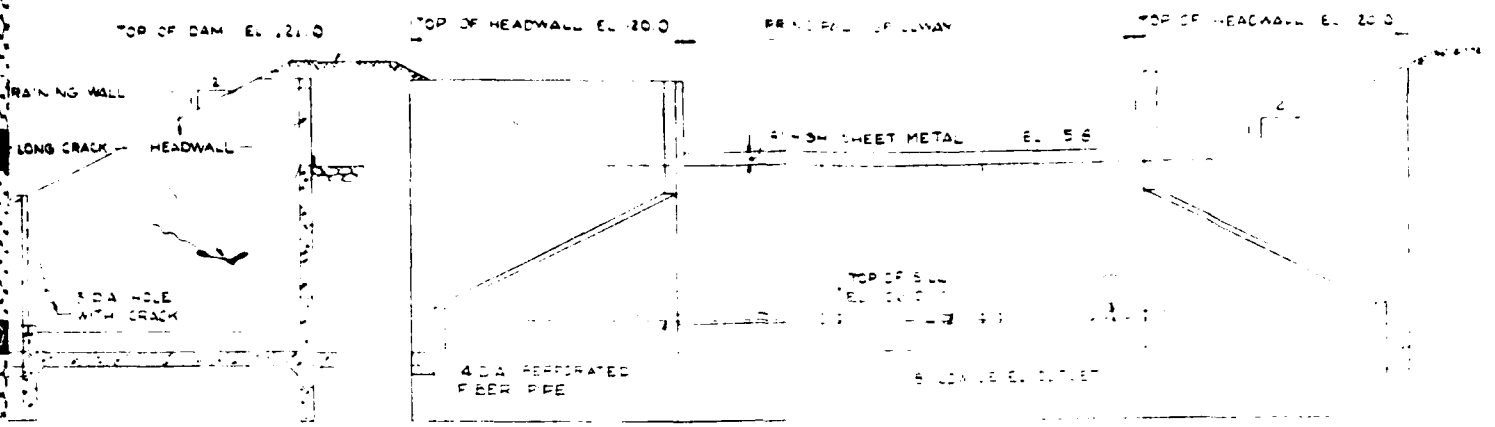
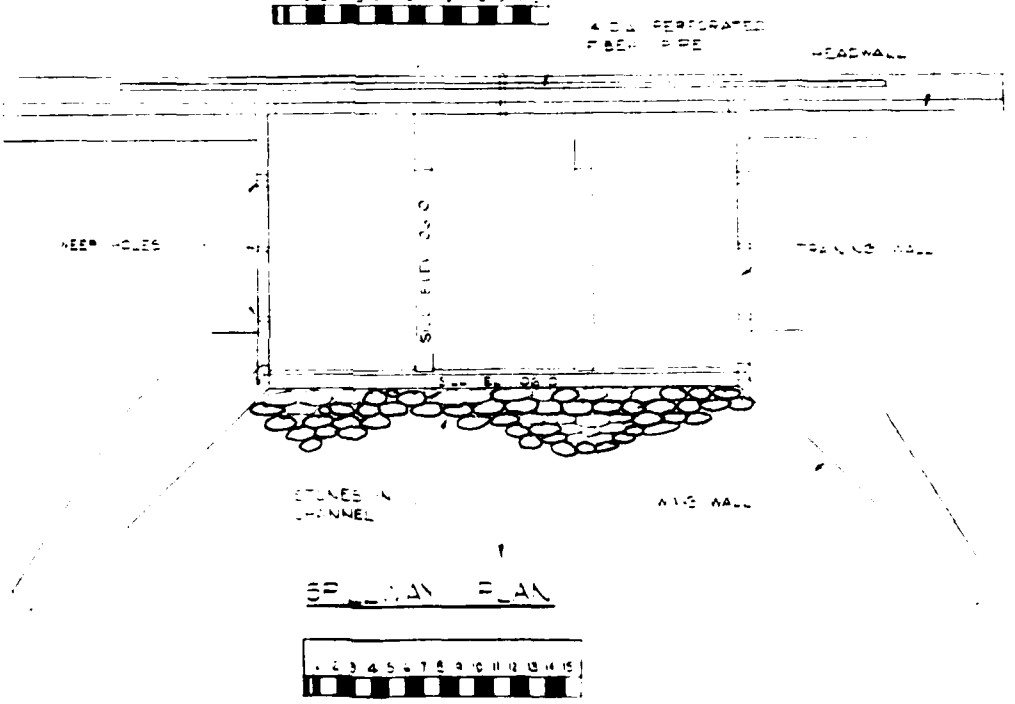
NATIONAL PROGRAM OF INSPECTI
PLAN, ELEVATION &
BUTTERWORTH PO

BUTTERWORTH BROOK

DRAWN BY	CHECKED BY	APPROVED BY	SCALE
M C			DATE





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INVERT EL 108.0

CAHN ENGINEERS INC WALLINGFORD, CONNECTICUT ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

PLAN, ELEVATION & SECTION

BUTTERWORTH POND DAM

BUTTERWORTH BROOK HAMDEN, CT.

DRAWN BY	CHECKED BY	APPROVED BY	SCALE AS NOTED
M.C.			DATE JUNE 1981 SHEET 8

BUTTERWORTH DAM

EXISTING PLANS

Set of 7 Sheets
Drawn By:

U.S. Department of Agriculture
Soil Conservation Service
Revised: November, 1962
Includes:

1) Plan View of Structure and Earth Embnakment
2) Plan View
3) Water Surface Profiles
4) Cross Sections and Profiles
5,6,7) Structural Detials of Spillway

SUMMARY OF DATA AND CORRESPONDENCE

DATE	TO	FROM	SUBJECT	PAGE
July 31, 1961	Files	U.S. Soil Conservation Service	Preliminary Geologic investigation	B-4
Aug. 21, 1961	Files	U.S. Soil Conservation Service	Design computations	B-5
June 27, 1962	Water Resources Commission	Frank Butterworth, Jr.	Construction applicaiton	B-18
July 9, 1962	Roger C. Brown, Blair Associates, Inc. Consultant to Water Resources Commission	Emitt A. Dell, Member, Water Resource Commission	Request for review of data and approval for construction	B-19
Aug. 7, 1962	T.R. Wire, Soil Conservation Service	Roger C. Brown	Request to redesign spillway to increase discharge capacity	B-20
Nov. 27, 1962	William S. Wise, Director Water Resources Commission	Roger C. Brown	Progress report on design review	B-21
Nov. 30, 1962	Roger C. Brown	R. R. Wire	Design revisions	B-22
Dec. 3, 1962	Emitt A. Dell	Roger C. Brown	Reoprt on design revisions	B-24
Dec. 4, 1962	Water Resources Commission	Frank Butterworth	Request for information	B-26

DATE	TO	FROM	SUBJECT	PAGE
Jan. 22, 1963	Emitt A. Dell	T.R. Wire	Job progress	B-27
Jan. 28, 1963	Roger C. Brown	Emitt A. Dell	Transmittal of Plans	B-28
Feb. 1, 1963	Files	Roger C. Brown	Memo - review of plans	B-29
Feb. 6, 1963	Emitt A. Dell	T.R. Wire	Transmittal of revised plans with specifications	B-30
Feb. 8, 1963	Emitt A. Dell	Roger C. Brown	Recommendation to issue construction permit	B-40
July 22, 1963	Frank Butterworth	William S. Wise	Construction Permit	B-41
Sept. 24, 1963	Roger C. Brown	William P. Sander Water Resources Commission	Request for final inspection	B-43
Oct. 7, 1963	William P. Sander	Roger C. Brown	Recommendaitons on issuance of Certificate of Approval	B-44

Form SCS-375
Sheet 1 of ___
For In-Service Use Only

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

10-59

PRELIMINARY GEOLOGIC INVESTIGATION OF DAM SITES

State Connecticut County New Haven ___ ¼ ___ ¼, Section ___, T ___ R ___ Date 7/31/61

Watershed ___ Subwatershed ___ Site no. ___ Investigated by W.M. Brown (signature of geologist)

Drainage area: 2.5 sq. mi., 1600 acres. Site group ___ Structure class B_C or ___ Fund classification CO-1 CN (WP-1, FP 2, etc.)

Embankment: Length 200 ft; Height 18 ft; Cubic yards ___. Purpose(s) of structure ___

This investigation made by: Inspection of surface X Hand auger ___ Test pits X Other (specify) ___

GENERAL GEOLOGY

Physiographic description Central Conn. Valley Geologic formation(s) Triassic New Haven Arkose with associated Triassic intrusives Attitude: Dip 5° SE Strike NE

Direction of valley axis (downstream) SW Steepness of abutments: Left 20 percent, Right 40 percent

Material of abutments Very loose fine to medium grained sands with associated gravels and cobbles. Siltstone in N. abutment at 8.0 ft.

Surficial deposits Sandy till with boulders at higher elevations. Sands and gravels at lower stream valley elevations.

Faults, folds, joints, caverns, and slide areas (describe briefly): The site area is cut by Triassic intrusives which are responsible for local topographic expression.

FOUNDATION

Geologic description Valley bottom: silty gravelly sand to 4.5 feet becoming dense at 7.0 feet. Siltstone and hardpan at that depth.

Depth to rock 7.0' Type of rock Siltstone Depth to groundwater 3.2' Date measured 7/31/61

Leakage problems None anticipated at valley bottom. Abutment seepage may be critical.

EMERGENCY SPILLWAY

Best location: Left abutment - Right abutment - Other Concrete weir at center of fill.

Estimated excavation: Volume - yds.; Percent rock -; Suitable for fill? - Type - (GC, CL, etc.)

Erodibility of control section: - (high, medium, low or very low) Erodibility of exit channel: - (high, medium, low or very low)

STREAM OR OUTLET CHANNEL

Description: width 5-7 ft., Depth 1-2 ft., Bed material Sands & gravels Median size of bed material ¼-½ est. in.

Channel: Scouring ___ Aggrading X Stable ___; Banks: Eroding X Stable ___

(continued on reverse side)

SCS-319
6-58

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

HYDROGRAPH COMPUTATION

Peak Discharge
10 yr. - 24 hour storm

WATERSHED OR PROJECT Butterworth Pond STATE Connecticut

STRUCTURE SITE OR SUBAREA

DR. AREA 2.34 SQ. MI. T_c 2.0 HR. RUNOFF CONDITION NO. II

RUNOFF CURVE NO. 68 . STORM DISTRIB. CURVE 3 . HYDROGRAPH FAMILY NO. 3

STORM DURATION 24 HR. RAINFALL: POINT — IN. AREAL 4.9 IN.*

Q 1.81 IN. COMPUTED T_p 1.4 HR. T_o 16.8 HR.

$(T_o + T_p)$: 1133 COMPUTED 12 : USED 10 . REVISED T_p 1.68

$q_p = \frac{484\ A}{REV.\ T_p}$ = 674 CFS. Qq_p = 1220 CFS. X

Ck DTB Oct.'61

t(COLUMN) = (t/T_p) REV. T_p. q(COLUMN) = (q_c/q_p) Qq_p

* U.S.W.B. T.P.-29

LINE NO.	t HOURS	q CFS	LINE NO.	t HOURS	q CFS	LINE NO.	t HOURS	q CFS
1			21			41		
2			22			42		
3			23			43		
4			24			44		
5			25			45		
6	4.5	370	26			46		
7			27			47		
8			28	24.5		48		
9			29			49		
10			30			50		
11			31			51		
12			32			52		
13			33			53		
14			34			54		
15			35			55		
16			36			56		
17			37			57		
18			38			58		
19			39			59		
20			40			60		

PEAK DISCHARGE FROM WATERSHED

SCS-310
6-58

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

HYDROGRAPH COMPUTATION — Peak Discharge 100 yr. - 24 hour storm

WATERSHED OR PROJECT Butterworth Pond STATE Connecticut

STRUCTURE SITE OR SUBAREA

DR. AREA 2.34 SQ. MI. T_c 2.0 HR. RUNOFF CONDITION NO. II

RUNOFF CURVE NO. 68 . STORM DISTRIB. CURVE B . HYDROGRAPH FAMILY NO. 3

STORM DURATION 24 HR. RAINFALL: POINT ____ IN. AREAL 7.0 IN. *

Q 3.41 IN. COMPUTED T_p 1.4 HR. T_o 17.9 HR.

$(T_o \div T_p)$: 1133 COMPUTED 13.8 : USED 10 . REVISED T_p 1.79

$q_p = \frac{484\ A}{REV.\ T_p}$ = 633 CFS. Qq_p = 2159 CFS.

3.41 × 633 =

t(COLUMN) = (t/T_p) REV. T_p. q(COLUMN) = $(q_c/q_p)\ Qq_p$ * U.S.W.B. T.P. - 29

LINE NO.	t HOURS	q CFS	LINE NO.	t HOURS	q CFS	LINE NO.	t HOURS	q CFS
1			21			41		
2			22			42		
3			23			43		
4			24			44		
5			25			45		
6		654	26			46		
7			27			47		
8			28			48		
9			29			49		
10			30			50		
11			31			51		
12			32			52		
13			33			53		
14			34			54		
15			35			55		
16			36			56		
17			37			57		
18			38			58		
19			39			59		
20			40			60		

PEAK DISCHARGE FROM WATERSHED

Conn. Butterworth Pond Site

MG 8/21/61

Rainfall Intensity - Frequency - Duration

From Technical Paper #29 U.S.W.B.

Rainfall - inches	Ratio of 2 yr to 100 yr.	100 year precipitation - inches
2 yr - 1 hr. = 1.3	$R = \frac{100\ yr - 1\ hr}{2\ yr - 1\ hr} = 2.2$	1 hr = 2.9
2 yr - 6 hr. = 2.5	$R = \frac{100\ yr - 6\ hr}{2\ yr - 6\ hr} = 2.0$	6 hr. 6.0
2 yr - 24 hr = 3.5	$R = \frac{100 yr - 24\ hr}{2\ yr - 24\ hr} = 2.0$	24 hr. 7.0

24 HOUR PRECIP. (Areal)	
Frequency Year	inches
10	4.90
25	5.60
50	6.25
60	6.45
70	6.65
80	6.75
90	6.85
100	7.00

Conn. Butterworth Pond Site

M.D. 8/21/61

Velocity in Watershed Course Reach for Time of Concentration Determination

Reach	Area feet^2	Perim. feet	R *	S	N	Velocity f.p.s.	Reach Length feet	Reach Travel time seconds
0-1	Memo 26 Hydrology 2			0.15		1.7	800	470
1-2	"			0.13		1.7	1200	700
2-3	"			0.05		1.0	750	750
(a) 3-4			0.3	0.05	0.045	3.6	1500	420
(a) 4-5			0.5	0.03	0.045	3.6	1650	460
(a) 5-6			0.7	0.02	0.045	3.7	3000	810
6-7	Pond			-		0.5	300	600
(a) 7-8			0.8	0.015	0.045	3.4	3000	880
8-9	Pond					0.5	500	1000
(a) 9-10	12		1.0	0.01	0.045	3.3	3300	1000
							16 800	7090
								1.97
								= 2.0 Hrs

* Estimated

(a) Hydraulic Tables - Corps of Engr's.

Conn. Butterworth Pond Site

MD 8/21/61

Watershed Runoff Curve No. - Watershed Area

(1) Soil Group	(2) Cover	(3) %	(4) Curve Number	3 x 4
B	Orchard	4.0	64	2.6
B	Hayland	24.0	69	16.6
C	Woodland	62.0	66	40.9
D	Woodland	10.0	74	7.4

Runoff II Condition Curve No = 67.5

Use 68

Watershed Area

Based on 1:24000 U.S.G.S. Topo

Area in inches^2 = 16.37

= 1500 acres

= 2.35 miles^2

Connecticut — Butterworth Pond Site

F.D. 8/21/61

Watershed Stream Slope Data

Watershed	Course & Sewer	Reach Length	Elevation In Feet	Difference in Elev.	Slope
Ditch-mongo Pk.					
6- 1	Woodland	600	700-580	120	0.15
1-	Woodland	1200	580-420	160	0.13
2- 4	Woodland	750	420-380	40	0.05
4- 5	Stream	1500	380-310	70	0.05
5- 5	Stream	1650	310-260	50	0.03
5- 6	Stream	3000	260-195	65	0.02
6- 7	Pond	300	195 -	-	
7- 8	Stream	3000	190-145	45	0.015
8- 9	Pond	500	145-	-	
9-10	Stream	9300	140-105	35	0.01
		16,000			

Comp. Butterworth Pond

D.T.B. 31 Aug 1961

River Road Bridge Capacity (Hydraulic)

Consider Bridge as open channel

		Flowing Full	
Area	= [illegible] ft^2	Area	= 56 ft^2
W.P.	= 21 ft	W.P	= 31 ft
R	= 2.6	R	= 1.8
S	= .007	S	= .007
n	= .030	n	= .030
V	= 8.2 f.p.s	V	= 6.1 f.p.s
q	= [illegible] c.f.s.	q	= 340 c.f.s.

Consider Bridge as Short tube flowing full

$$q = C A \sqrt{2g\left(H + \frac{v^2}{2g}\right)}$$

v determine from next upstream section

$$= 0.80 \times 56 \sqrt{2g\left(2.0 + \frac{5.8^2}{2g}\right)}$$

v = [illegible] f.p.s

A = [illegible] ft^2

$$= 44.8 \sqrt{161}$$

C = 0.8[illegible] from Table 12 Hinds Hydraulics

$$= 570 \text{ c.f.s.}$$

H = 2

Conn. Butterworth Brook

Butterworth Brook Channel Slope

Cross-Section	Station	Elevation Channel Bottom	Channel Slope
	0 + 50	97.0	
1	1 + 50	96.8	
			$\frac{0.7}{290}$
2	2 + 24	96.9	= .0024
3	2 + 86	96.8	
	3 + 41	96.1	
	3 + 92	95.7	
4	5 + 12	95.3	$\frac{1.5}{305}$
5	5 + 99	94.9	= .005
6	6 + 87	94.2	

COMPUTATION SHEET
SCS-523 REV 8-58

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE | PROJECT BUTTERWORTH
BY | DATE | CHECKED BY | DATE | JOB NO

SUBJECT DETERMINATION OF TOP OF DAM SHEET OF

SEE PAGE 3-12 - SECTION 11, NEH

— Depth of flow in weir notch -

$$Q = \frac{3.1\ L\ h^{3/2}}{(1.10 + .01F}$$

$$\text{depth of flow} = \left(\frac{Q}{3.1\ L}\right)^{2/3}$$

$$= 4.04$$

$$h^{3/2} = \frac{Q\,(1.10 + .01 \times 9)}{3.1 \times L}$$

$$h = \left(\frac{654(1.10 + .09)}{3.1 \times 26}\right)^{3/2}$$

$$= \left[\frac{654 \times 1.19}{80.6}\right]^{3/2}$$

$$= 9.66^{3/2}$$

$$= 4.54 \quad \text{INCLUDES FREE BOARD}$$

$$\text{FREEBOARD} = FW = 95 \times 10^{-6} \times D + \frac{F^{1/2}}{2} + 0.27$$

WHERE D = FETCH = 1000'

HENCE: $FW = 95 \times 10^{-3} + 1.5 + 270 \times 10^{-3}$

$$= 1.87'$$

THEREFORE TOP OF DAM IS

$$115 + 4.04 + 1.87 = 120.9$$

SAY 121.0

COMPUTATION SHEET
SCS-523 REV 5-58

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE CONN PROJECT

BY DTB DATE CHECKED BY DATE JOB NO

SUBJECT PRINCIPAL DIMENSIONS OF SPILLWAY SHEET OF

SEE ENG. HANDBOOK - DROP SPWY's SECTION 11
ES 67 SHEET 1 OF 1 (TYPE B)
TOP OF SILL = 106'
CREST WEIR = 115'
HEADWALL Extension = 119.5'

$h = 4.5'$ = TOP HEADWALL MINUS CREST WEIR
Depth of weir

$S = h/3 = 1.5'$

$F = 9'$

$L_N = 26'$

$L_{BASIN} = 14.94' - L_L = F\left[2.28\left(\frac{4.5}{9}\right) + 0.52\right] = 14.94$

$L_B/F = 1.66$

$h/F = 0.5$

$E = 15.5'$ $3 \times 4.5 + 2 = 15.5'$ use this
$1.5 \times 9 = 13.5'$

$J = 9'$

$M = 12' = 2[9 + (6-9)]$

$K = 3.36'$ $(14.94 + 0.42) - 12$

Conn

Butterworth

DTB

Minimum Tailwater

$$d_c = \sqrt[3]{q^2/g}$$

$$= \sqrt[3]{\left(31\%_{26}\right)^2/32.2}$$

$$= 1.9'$$

t_{min} can vary from 2.4' to 2.0'

From water surface profiles we get $t = 3.71'$ @ ℄ Dam

hence minimum tailwater okay

COMPUTATION SHEET
SCS-523 REV 5-88

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE CONN PROJECT

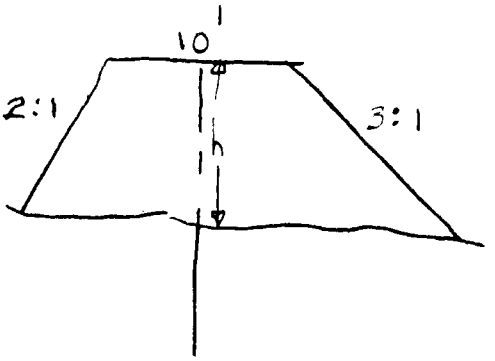
BY STD DATE JUNE 94 CHECKED BY DATE JOB NO

SUBJECT YARDAGE CALCULATIONS OF SHEET OF

Area $\frac{1}{2}xh \times 2h + \frac{1}{2}h \times 3h + 10h$

$= \frac{1}{2}(2h^2 + 3h^2) + 10h$

$= \frac{5}{2}h^2 + 10h$



	STA	END AREA D'	Σ END AREA	AVE END AREA	Distance ℄	VOL cu ft	ACC VOL
	4+85	0					
			80	40	15	600	
	4+70	80					
			633	317	40	12,680	13,280
	4+30	553					
			1106	553	90	49,770	63,050
pie shaped	3+40	553					
			873	437	15	6,555	69,605
pie shaped	3+25	320					
			640	320	27	8,640	78,245
	2+98	320					
			320	106	30	3,180	81,425
	2+63	0					

3016 yd³

CONN BUTTERWORTH POND
DT6
QUANTITY VALUES FOR STRUCTURE

CONCRETE	—	71	YARDS 70.76
EARTH FILL	—	3100	YARDS
FILTER MATERIAL	—	128	YARDS
REINF. STEEL	—	8572	POUNDS 8517.17
18" ACCM PIPE	—	50	FEET
4" PERFORATED DRAIN	—	12	FEET
1 18" GATE			

FORM D-4

STATE OF CONNECTICUT
WATER RESOURCES COMMISSION
Room 317, State Office Building
Hartford, Connecticut

U S COMMISSION
RECEIVED
JUL 5 1962
ANSWERED
REFERRED
FILED

APPLICATION FOR CONSTRUCTION PERMIT FOR DAM

Owner FRANK BUTTERWORTH-JR Date 6/29/62

P. O. Address TITTLE AVE. MT CARMEL, CONN Tel. No. CH 9-3213

Location of Structure:

Town Hamden Shown on USGS Quadrangle

Name of Stream at inches south of Lat. north
and inches east of Long. west

Directions for reaching site from nearest village or route intersection:
(see sketch on reverse side)
N on Rte 10 from Mt. Carmel Center, 1st River Rd. (just beyond Sleeping Giant Park Comm) about ½ mile, across Mill River & brook just below site of dam.

This is an application for: (New Construction) (Alteration) (Repair) (Removal)
(check one or more of above)

This pond is to be used for: Wildlife

Dimensions of Pond: width length area 9 acres

Maximum depth of water immediately above dam: 10'

Total length of dam:

Length of spillway:

Height of abutments above spillway:

Type of spillway construction:

Type of dike construction:

Spillway section will be set on: (Bedrock) (Gravel) (Clay) (Till)
(check one of above)

Remarks:

Signed: Frank Butterworth Jr.
(owner)

Name of Engineer, if any

Note: Show details of construction on reverse side.

STATE OF CONNECTICUT

WATER RESOURCES COMMISSION
STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

July 9, 1962

Mr. Roger C. Brown
Blair Associates, Inc.
Consulting Engineers
93 Whitney Avenue
New Haven, Connecticut

Re: Butterworth Pond
Hamden, Connecticut

Dear Mr. Brown:

Under your terms as a consultant to this office would you take whatever action you deem necessary so that this office can issue a construction certificate.

Respectfully,

Emitt A. Dell

Emitt A. Dell
Field Inspector

EAD:js
Enclosures

Received July 11, 1962
RWB

August 7, 1962

Mr. T. R. Wire
Soil Conservation Service
Old Bookstore Building
Storrs, Connecticut

Dear Mr. Wire:

Plans and design computations for a dam for Frank Butterworth, Tuttle Avenue, Mount Carmel have been referred to me for review by the State Water Resource Commission.

From the standpoint of safety I am particularly interested in the capacity of the overflow section.

The design computations indicate a peak discharge from the 2.34 square miles of drainage area of 654 cfs.

A considerable portion of the drainage area lies along the northern slope of Mount Carmel and is on an extremely steep and rocky shed. In view of the size and character of the drainage area it is my opinion that the peak discharge used in the design of the spillway is not large enough for safety.

The unit peak discharge of $\frac{654}{2.34}$ = 280 cfs per square mile used in this design was exceeded in many instances on small watersheds in Connecticut and Massachusetts during the floods of August and October of 1955.

I would think that the design discharge should be considerably larger than the value you have used and I would like to discuss this matter with you if it can be arranged.

Very truly yours,

CALARENCE BLAIR ASSOCIATES, INC.

Roger O. Brown

ROB:awp
cc: Mr. Emitt A. Deli
Water Resources Commission

CLARENCE BLAIR ASSOCIATES, INC.

Civil Engineers

P. O. BOX 886 SPRUCE 7-7879

98 WHITNEY AVENUE — NEW HAVEN, CONN.

ROGER C. BROWN
JAMES G. BEACH
FRANK RAGAINI

CHARLES S. AUGUR, JR.
GORDON BILIDES
JOHN M. BREST
DONALD L. DISBROW
NICHOLAS PIPERAS, JR.

WATER SUPPLY
SEWAGE DISPOSAL
WASTE DISPOSAL
SURVEYS
LAND DEVELOPMENT

November 27, 1962

Mr. William S. Wise, Director
State Water Resources Commission
650 Main Street
Hartford 15, Connecticut

Re: Butterworth Dam
Hamden, Conn.

Dear Mr. Wise:

On July 11, 1962 I received for review, plans of the subject dam designed by the Soil Conservation Service for Frank Butterworth, Jr., Tuttle Avenue, Mount Carmel, Connecticut.

On August 7th I wrote to Mr. T. R. Wire of the Soil Conservation Service saying that I did not agree with the design peak discharge arrived at in their computations and that I would like to discuss the matter with him. I did not receive any reply from Mr. Wire.

Last week I received a call from Mr. Dell informing me that construction was in progress on the dam in spite of the fact that no permit has ever been issued.

I then called Mr. Wire who came to my office this morning to discuss the design. Their design is based on a storm of 100 year frequency and a peak discharge of 280 cfs per square mile. This unit discharge was exceeded in many cases on comparable watersheds in Connecticut and Massachusetts in the floods of 1955.

The question of what criteria should be used in the design of a structure of this sort is an important one and if possible I would like to discuss the matter with one of the other consultants, preferably Mr. Cone, before making a ruling.

Very truly yours,

Roger C. Brown

Roger C. Brown

RCB:mmm

Old Bookstore Building
Stowe, Connecticut

November 30, 1962

Clarence Blair Associates, Inc.
93 Whitney Avenue
New Haven, Connecticut

Attention: Mr. Roger C. Brown

Gentlemen:

It is regrettable that it was necessary to rush through discussion on the Butterworth design and must offer my apologies since the delay was due to my leaving aside your letter after returning from my vacation this summer and failing to make the necessary answer. The Service is aware that construction should not start until after a permit is issued and the neglect on the procedure is my fault.

The proposed modification as we discussed by phone is practical and will not cause Mr. Butterworth or the contractor any delay or change of any real consequence, and under the circumstances I am will satisfied with your decision.

My original determination that 100 year frequency storms should be adequate to meet Connecticut criteria was based on the fact that for 26 years in other areas this type of structure had been designed for 25 and 50 year frequency storms without any failures due to inadequate capacity.

Modification will be made on this site in accord with our discussions to provide emergency capacity on the following points:

1. Raise the head wall extensions 0.5 feet thereby having a spillway 5' x 26'.

2. Provide an emergency spillway overlap of the north end of the earth levee by raising the top elevation 119.0 for a distance of 80 feet and reducing the downstream embankment slope to 4:1 along this area. The level top width of the emergency spillway will be 20 feet.

Assuming water surface at elevation 120.0, this will provide a possible maximum discharge without damage to the structure of 1090 c.f.s.

Delaware Water Associates, Inc.-11/30/62

Your attention to these discussions to facilitate issuance of the construction permit is appreciated.

Sincerely yours,

T. R. Wire

T. R. Wire
State Conservation Engineer

cc: Mr. Ralph A. Bell
United States Government Commission
Enclosure
Bell

CLARENCE BLAIR ASSOCIATES, INC.

Civil Engineers

P. O. BOX 836 SPRUCE 7-7878

93 WHITNEY AVENUE — NEW HAVEN, CONN.

ROGER C. BROWN
JAMES C. BEACH
FRANK RAGAINI

CHARLES E. AUGUR, JR.
GORDON BILLINGS
JOHN M. BREST
DONALD L. BIGBROW
NICHOLAS PIPERAS, JR.

WATER SUPPLY
SEWAGE DISPOSAL
WASTE DISPOSAL
SURVEYS
LAND DEVELOPMENT

December 3, 1962

Water Resources Commission
650 Main Street
Hartford 15, Connecticut

Attention: Mr. Emitt A. Dell

Re: Butterworth Dam
Hamden, Conn.

Gentlemen:

Reference is made to my letter to Mr. Wise dated November 27 reviewing the developments in connection with the subject dam.

On the morning after I had written that letter, Mr. Wire called me with some suggested changes in design and after some discussion we agreed on modifications which would satisfy my requirements for additional spillway capacity.

These modifications are set forth in Mr. Wire's letter to me dated November 30, 1962, a copy of which was sent to Mr. Dell.

I recommend the issuance of a Construction Permit for the dam as shown on the original plans with the following modifications quoted from Mr. Wire's letter:

"Modification will be made on this site in accord with our discussions to provide emergency capacity on the following points:

1. Raise the head wall extensions 0.5 feet thereby having a spillway 5' x 26'.

2. Provide an emergency spillway ~~overtop~~ over the top of the north end of the earth levee by making the top elevation 119.0 for a distance of 80 feet and reducing the downstream embankment slope to 4:1 along this area. The level top width of the emergency spillway will be 20 feet.

Assuming water surface at elevation 120.0, this will provide a possible maximum discharge without damage to the structure of 1090 c.f.s."

Water Resources Commission December 3, 1962

Since a satisfactory design has been arrived at, I withdraw my request for permission to call in another consultant.

Enclosed are the originals of Form D-1 and D-4 for this project.

Very truly yours,

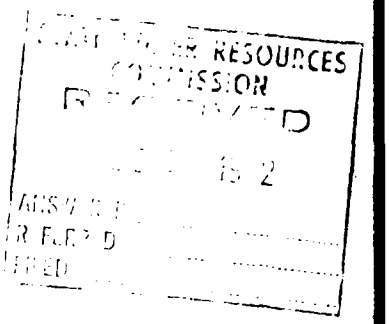
Roger C. Brown

Roger C. Brown

RCB:mmm
Encls.
cc: Mr. T.R. Wire
State Conservation Engineer

& 2341

FORM D-1



REQUEST FOR INFORMATION

Date: _____

State of Connecticut
Water Resources Commission
Room 317, State Office Building
Hartford 15, Connecticut

Gentlemen:

I propose to construct a Dam (describe proposed structure)
on ? (name of stream) in the Town of Hamden.
The site may be reached from Mt. Carmel by proceeding (north)
(south) (east) (west) on Route No. 10, turn right on Rivers Rd.
(describe specifically
(just beyond Sleeping Giant Golf Course), cross Mill River &
means of reaching site)
turn first hilow site of dam.

The proposed construction will create a pond of 9 acres, having a maximum depth of 10 feet.

Would you please inform me whether or not a Construction Permit will be required.

Very truly yours,

Frank Tuttle Jr.
(Name)
Tuttle Agy.
Mt. Carmel, Ct.
(Address)

Tel. No. CH 4-3213

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Old Bookstore Building
Storrs, Connecticut

January 22, 1963

Water Resources Commission
650 Main Street
Hartford 15, Connecticut

Attention: Emitt A. Dell, Field Inspector

Gentlemen:

Regarding your call on the Butterworth Dam, enclosed are three prints of the plans for this dam. It was not indicated if additional structural details were necessary. These can be provided if necessary. Since the indicated modifications can be shown on the plans, only these prints are forwarded at this time.

No detailed specifications were proposed for this job. Class B, 3000 pound, concrete is specified on the structural details. Other than this requirements of the work have been discussed with the contractor as work progresses.

No work is being done on this site at present because of cold weather.

Sincerely yours,

T. R. Wire

T. R. Wire
State Conservation Engineer

Growth Through Agricultural Progress

January 28, 1963

Mr. Roger C. Brown
Consulting Engineer
93 Whitney Avenue
New Haven, Connecticut

Re: Butterworth Dam
Hamden, Connecticut

Dear Roger:

Enclosed please find set of plans forwarded this office by Mr. T. R. Wire. I trust this takes care of all the modifications you asked for in one of your letters to Mr. Wire. I am also enclosing a page from the Commission meeting showing the disposition of Butterworth Dam.

Respectfully,

Emitt A. Dell
Field Inspector

EAD:mac
enclosures

February 1, 1963

OFFICE MEMO

State Board
Butterworth Dam

I received this morning a letter from Mr. Dell enclosing three prints of Butterworth Dam together with a letter from Mr. Wire to Dell dated January 22nd and an item from the (minutes of the meeting of the Commission ?) - which says that the Commission voted unanimously to issue the construction permit with certain modifications as suggested by the Consultant.

The three prints enclosed showed no change from the originals. My recommended changes had not been incorporated in these plans. I called Dell and he said that permit had not been issued. He had requested Wire to send him corrected prints and Dell assumed that these prints sent to him were revised.

I called Wire directly. He knew that the prints had not been revised but thought that Dell wanted additional copies of the old prints. Wire will make the requested changes on the originals and get new prints. He will send two sets to Dell and one set directly to me.

I also discussed with Wire the subject of specifications for the earth fill. He will include on the plans or on a separate sheet, some reference to such specifications.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Old Bookstore Building
Storrs, Connecticut

February 6, 1963

Water Resources Commission
650 Main Street
Hartford 15, Connecticut

Attention: Emitt A. Dell, Field Inspector

Gentlemen:

In connection with the revisions of the Butterworth Dam, Mr. Brown suggested that the revisions outlined in my letter of November 30, 1962 be made on the original tracings and the plans reprinted.

Enclosed are two sets of revised prints. Previous prints of these four sheets should be destroyed. Also attached are copies of standard specifications applicable to this job.

Revised plans are being forwarded directly to Mr. Brown and Mr. Indorf.

Sincerely yours,

T. R. Wire

T. R. Wire
State Conservation Engineer

cc: Mr. Roger C. Brown
Mr. Frank E. Indorf, Jr.

Grow Through Agricultural Progress

MAP Received 2-7-63
in MAP file

CONSTRUCTION SPECIFICATIONS

Number 2
EARTH FILL

I. Scope. This item shall include the excavation, transportation, and placement of materials and the performance of other operations in connection with the construction of the earth fill dam as shown on the drawings or as herein specified.

II. Material. The material for the fill shall be obtained from the designated areas. The material shall be free from stumps, wood, brush, roots, sod, rubbish, and other matter that may decay. It should also be free of stones over two (2) inches in diameter where compacted by hand or mechanical tampers, or over six (6) inches in diameter where compacted by rollers or other equipment. Frozen material shall not be placed in the fill, nor shall the fill material be placed on a frozen foundation.

III. Preparation of Foundation. Upon completion of the stripping operation and just prior to placing the fill material on any portion of the foundation, that portion shall be scarified, plowed, or disked to a depth of three (3) inches. All objectionable material exposed by this operation shall be disposed of outside the limits of the fill.

IV. Core Trench. Where specified, a core trench shall be excavated along or parallel to the central axis of the earth fill as shown on the plans. The width of the trench shall be governed by the equipment used for excavation, with the minimum width being four (4) feet.

If a core trench is needed the minimum depth shall be three (3) feet or the depth shown on the plans. If large boulders or bedrock is encountered in the excavation, the minimum depth will not be required if, in the opinion of the Engineer, the trench cannot be excavated to the required depth. The rock or boulders shall be cleared of all materials to insure adequate bonding of backfill material to the rock. The side slopes of the trench shall be 1 on 1 or flatter.

The backfill material for the core trench shall be the most impervious material available and shall be compacted with equipment or rollers to assure maximum density and minimum permeability. Where rock is encountered, the fill material shall be placed in three-inch layers and compacted by hand or mechanical tampers. The fill material shall contain sufficient moisture to insure adequate bonding to the rock. Backfilling shall continue in three-inch layers until the depth of fill over the rock is such that acceptable density may be obtained by using construction equipment with a maximum of six-inch layers for the compaction operation.

APPROVED [signature] HEAD OF E. & W.P. UNIT DATE 1-60

REFERENCE
BUTTERWORTH
C-NH-3004

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING & WATERSHED
PLANNING UNIT
UPPER DARBY, PENNSYLVANIA

DRAWING NO
ESNE-76
SHEET 1 OF 3
DATE JAN, 60

CONSTRUCTION SPECIFICATIONS

Number 2
EARTH FILL

V. Imbedded Conduits. Imbedded conduits shall mean pipes installed for the purpose of draining the reservoir, pipe spillways, pipes for stock watering developments, or other pipes or conduits installed or existing under the fill.

Excavation for conduits shall be made to grades and lines shown on the plans or as indicated by construction stakes. Care should be taken not to excavate below the depths specified. Excavation below grade shall be corrected by placing firmly compacted layers of earth to provide a good foundation. If rock or boulders are exposed in the bottom of the excavation, they shall be removed to a minimum depth of eight (8) inches below the invert grade of the pipe and the excess excavation replaced with firmly compacted earth to the specified grade.

The pipe shall be installed and the excavation backfilled as specified in paragraph VIII before starting the placement of the earth fill.

VI. Placing and Spreading Material. The placing and spreading of material shall be started at the lowest part of the section under construction and the fill carried up in layers of six (6) inches. The layers shall slope slightly towards the reservoir to prevent puddles and provide for faster runoff in case of rain. Where possible, the layers should extend over the entire area of the fill. The distribution and gradation of the materials throughout the fill shall be such that there be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. The most porous borrow material shall be placed on the downstream portions of the embankment.

VII. Compaction. Each layer of fill material shall be compacted by routing the construction equipment so that all parts of each layer are equally compacted. Bulldozers, carry-alls, trucks, farm tractors, or rollers may be used for the compaction. Fill material should contain sufficient moisture so that it can be formed into a ball without crumbling. If water can be squeezed out of the ball, it is too wet to compact properly.

VIII. Backfill Adjacent to Structures. After the forms are removed from concrete structures, the excavation shall be cleared of all trash and debris prior to backfilling. The fill shall be placed in horizontal layers not to exceed four (4) inches in thickness and compacted by hand tampers or other compaction equipment. At no

APPROVED [signature] HEAD OF E. & W. P. UNIT DATE 1-60

REFERENCE	U. S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-76 SHEET 2 OF 3 DATE JAN, 60

CONSTRUCTION SPECIFICATIONS

Number 2
EARTH FILL

time during the backfilling operation shall driven equipment be allowed to operate closer than four (4) feet, measured horizontally, to any portion of a structure. Under no circumstances shall the contractor drive equipment over any part of a concrete structure or pipe unless there is a compacted fill of twenty-four (24) inches or greater over the structure or pipe.

APPROVED [signature] HEAD OF E. & W. P. UNIT DATE 1-60

REFERENCE	U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-76 SHEET 3 OF 3 DATE JAN, 60

CONSTRUCTION SPECIFICATIONS

Number 3
PLAIN AND REINFORCED CONCRETE

I. Proportioning the Mix. The concrete shall be mixed in the following proportions, measured either by direct weight or volume. The water-cement ratio shall be 5-1/2 to 6 U. S. gallons of water per 94-pound sack of cement. The proportions of ingredients for the trial mix shall be 1:2:3-1/2. The combination of aggregates may be adjusted to produce a plastic and workable mix that will not produce harshness in placing or honeycombing in the structure.

II. Cement. Normal Portland cement shall conform to the latest A. S. T. M. Specifications C-150.

III. Water. The water used in concrete shall be fresh, clean, and free of silt, sewage, oil, acid, alkali, salts, or organic matter (drinkable water).

IV. Sand. Sand for concrete shall be clean, hard, strong, and durable and shall be well graded, with 100 percent passing a one-quarter-inch sieve.

V. Coarse Aggregate. Coarse aggregate shall be clean, hard, strong and durable, and free from clay or dirt. It shall be well graded with a maximum size of 1-1/2 inches.

VI. Mixing. The concrete ingredients shall be mixed in batch mixers until the mixture is homogenous and of uniform consistency. The mixing of each batch shall continue for not less than one and one-half minutes after all the ingredients, except the full amount of water, are in the mixer. The minimum mixing time is predicated on proper control of the speed of rotation of the mixer and of the introduction of the materials, including water, into the mixer. Water shall be added prior to, during, and following the mixer-charging operations. Excessive overmixing requiring the addition of water to preserve the required concrete consistency shall not be permitted. Truck mixing will be allowed provided that the use of this method shall cause no violation of any applicable provisions of the specifications given here.

VII. Forms. The forms shall have sufficient strength and rigidity to hold the concrete and to withstand the necessary pressure, tamping, and vibration without deflection from the prescribed lines. They shall be mortar-tight and constructed so they can be removed without hammering or prying against the concrete.

The inside of forms shall be oiled with a non-staining mineral oil

APPROVED [signature] HEAD OF E. & W.P. UNIT DATE 1-60

REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-77 SHEET 1 OF 2 DATE JAN, 60

CONSTRUCTION SPECIFICATIONS

Number 3
PLAIN AND REINFORCED CONCRETE

or thoroughly wetted before concrete is placed.

All wire ties and other devices used shall be cut off flush with the surface of the concrete after the forms are removed.

VIII. Reinforcing steel shall be deformed bars of intermediate grade billet steel or rail steel conforming to A. S. T. M. Specifications A-15 and A-16, respectively, and shall be free of dirt, rust, scale, oil, paint, or other coatings. Steel shall be accurately placed and securely held in position by wiring and blocking.

IX. Finishing. The surface of concrete finished against forms shall be smooth, free from projections, and filled thoroughly with mortar. Exposed, unformed surfaces of concrete shall be brought to a uniform surface and worked with suitable tools to a reasonably smooth wood-float or steel trowel finish. Excessive floating or trowelling of surfaces while the concrete is plastic will not be permitted.

X. Protection and Curing. Exposed surfaces of concrete shall be protected from the direct rays of the sun for at least the first three (3) days. All concrete shall be kept continuously moist for at least ten (10) days after being placed. Moisture may be applied by spraying or sprinkling as necessary to prevent the concrete from drying. Concrete shall not be exposed to freezing during the curing period.

XI. Placing Concrete. Concrete may not be placed at temperatures below 37° F. with the thermometer falling, or 34° F. with the thermometer rising.

APPROVED [signature] HEAD OF E. & W.P. UNIT DATE 1-60

REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-77 SHEET 2 OF 2 DATE JAN, 60

CONSTRUCTION SPECIFICATIONS

Number 4
PIPE CONDUITS
CORRUGATED METAL PIPE

I. Description. This item shall consist of furnishing and installing sections of corrugated metal pipe to provide a barrel and riser for a drop inlet, spillways, drain pipe, water pipe, or other pipe conduit placed under an earth fill. The pipe shall be the size and type specified.

II. Materials.

a. Corrugated Metal Pipe and fixtures shall conform to the requirements of A. A. S. H. O. Specification M-36. The inside and outside of the pipe and fixtures shall be completely coated with asphalt cement to a minimum thickness of 0.04 inch measured at the crest of the corrugations. The asphalt cement used for the coating shall not be less than 99.5 percent soluble in carbon disulphide and shall adhere tenaciously to the metal, shall not chip off in handling, and shall protect the metal from deterioration.

b. All pipe 18 inches in diameter and larger shall have double riveted seams.

III. Construction Methods.

a. Trench. The width of the trench in which the pipe is placed shall be sufficient to permit thorough tamping of the backfill under the haunches and around the pipe. A minimum width of 2'-0" + the outside diameter of the pipe is to be maintained.

b. Bedding. The pipe shall be bedded in an earth foundation of uniform density, shaped to fit the lower part of the pipe exterior for at least 10 percent of its height. Where rock is encountered, it shall be removed and replaced with suitable compacted earth to provide an earth cushion under the pipe of 8 inches. Where soft, spongy, or other unstable soil is encountered, all such unstable soil shall be removed and replaced with suitable earth compacted to provide adequate support.

IV. Laying Pipe. The pipe shall be placed with the inside circumferential laps pointing downstream and with the longitudinal laps at the sides. The joining of sections of pipe shall be done in a manner so as to secure a watertight joint. When using standard connecting bands, the 2 sections of pipe shall be placed in position and wrapped with 2 layers of heavy asphalt saturated

APPROVED [signature] HEAD OF E. & W.P. UNIT DATE 1-60

REFERENCE	U. S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-78 SHEET 1 OF 2 DATE JAN, 60

Number 4
PIPE CONDUITS
CORRUGATED METAL PIPE

roofing felt. The connecting band shall then be placed over the wrapping and securely clamped, with the bolts being placed at the top. When watertight bands are used for joining the sections of pipe, the laps shall be made at the top of the pipe and the rods so placed that the tightening lugs are also at the top. The whole line of pipe shall be true to line and grade, and any deviation shall be corrected before backfilling.

V. Backfilling. Material used for backfilling adjacent to the pipe shall be impervious soil free of large stones, frozen lumps, or debris. It shall be deposited alternately on opposite sides of the pipe in 4-inch layers and thoroughly tamped. Care shall be taken to provide good compaction under the haunches of the pipe. Equipment shall not be driven over any part of the pipe unless there is a compacted fill of 24 inches or greater over the top of the pipe.

VI. Anti-Seep Collars. Anti-seep collars shall be constructed of the materials specified to the dimensions and at the locations shown on the drawings.

VII. Junctions. Junctions of the conduit with the riser for drop inlets shall be made as shown on the drawings. Valves and other fixtures shall be placed as shown on the drawings.

APPROVED [signature] HEAD OF E. & W.P. UNIT DATE 1-60

REFERENCE	U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-78 SHEET 2 OF 2 DATE JAN, 60

CONSTRUCTION SPECIFICATIONS

Number 7
ROCK RIPRAP

I. SCOPE. This specification covers the foundation preparation for riprap and the placing of rock riprap.

II. MATERIALS. The riprap stone shall be durable and of suitable quality to assure permanence, and shall be reasonably well graded from a minimum of one inch diameter to a maximum size equal to the thickness of the riprap shown on the drawings.

III. FOUNDATION PREPARATION. Earth surfaces on which the rock riprap is to be placed shall be trimmed and graded to the lines or sections shown on the drawings. Surfaces which are below grade shall be brought to grade by filling with well compacted materials similar to the adjacent materials.

IV. PLACEMENT. The riprap shall be placed to the full course thickness shown on the drawings and in such a manner that will prevent serious displacement of the underlying material. The rock shall be placed so that the larger and heavier rocks are located at the base of the slope. The rock may be placed by any means, provided free fall does not exceed five (5) feet. The finished surface of the riprap will be fairly smooth and to the lines and grades shown on the drawings. Spaces between the larger rocks will be filled with smaller rocks of acceptable size so that no opening exceeding three (3) inches in diameter will remain.

When hand-placed riprap is called for on the drawings, the rock shall be placed by hand in such a manner that adjacent rocks are in close contact and have the greatest dimension across the slope.

APPROVED [signature] HEAD OF E. & W.P. UNIT DATE 1-60

REFERENCE	U. S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-81 SHEET 1 OF 1 DATE JAN, 60

CONSTRUCTION SPECIFICATIONS

Number 2
EARTH FILL

I. Scope. This item shall include the excavation, transportation, and placement of materials and the performance of other operations in connection with the construction of the earth fill dam as shown on the drawings or as herein specified.

II. Material. The material for the fill shall be obtained from the designated areas. The material shall be free from stumps, wood, brush, roots, sod, rubbish, and other matter that may decay. It should also be free of stones over two (2) inches in diameter where compacted by hand or mechanical tampers, or over six (6) inches in diameter where compacted by rollers or other equipment. Frozen material shall not be placed in the fill, nor shall the fill material be placed on a frozen foundation.

III. Preparation of Foundation. Upon completion of the stripping operation and just prior to placing the fill material on any portion of the foundation, that portion shall be scarified, plowed, or disked to a depth of three (3) inches. All objectionable material exposed by this operation shall be disposed of outside the limits of the fill.

IV. Core Trench. Where specified, a core trench shall be excavated along or parallel to the central axis of the earth fill as shown on the plans. The width of the trench shall be governed by the equipment used for excavation, with the minimum width being four (4) feet.

If a core trench is needed the minimum depth shall be three (3) feet or the depth shown on the plans. If large boulders or bedrock is encountered in the excavation, the minimum depth will not be required if, in the opinion of the Engineer, the trench cannot be excavated to the required depth. The rock or boulders shall be cleared of all materials to insure adequate bonding of backfill material to the rock. The side slopes of the trench shall be 1 on 1 or flatter.

The backfill material for the core trench shall be the most impervious material available and shall be compacted with equipment or rollers to assure maximum density and minimum permeability. Where rock is encountered, the fill material shall be placed in three-inch layers and compacted by hand or mechanical tampers. The fill material shall contain sufficient moisture to insure adequate bonding to the rock. Backfilling shall continue in three-inch layers until the depth of fill over the rock is such that acceptable density may be obtained by using construction equipment with a maximum of six-inch layers for the compaction operation.

APPROVED [illegible] HEAD OF E. & W.P. UNIT DATE 1-60

REFERENCE	U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	DRAWING NO ESNE-76 SHEET 1 OF 3 DATE JAN, 60
BUTTERNORTH C-NH-3004		

CLARENCE BLAIR ASSOCIATES, INC.

Civil Engineers

P. O. BOX 236 SPRUCE 7-7379

93 WHITNEY AVENUE — NEW HAVEN, CONN.

ROGER C. BROWN
JAMES C. BEACH
FRANK RAGAINI

CHARLES E. AUGUR, JR.
GORDON BILIDES
JOHN M. BREST
DONALD L. DIBBROW
NICHOLAS PIPERAS, JR.

WATER SUPPLY
SEWAGE DISPOSAL
WASTE DISPOSAL
SURVEYS
LAND DEVELOPMENT

February 7, 1963

Water Resources Commission
650 Main Street
Hartford 15, Connecticut

Re: Butterworth Dam
Hamden, Conn.

Attention: Mr. Emitt A. Dell

Gentlemen:

I have received today from Mr. Wire, State Conservation Engineer, revised plans of the subject dam.

You will recall that in my letter to you dated December 3, I recommended that a Construction Permit be issued subject to certain modifications in the plans as agreed to by Mr. Wire and myself.

These changes have been made on the plans which I received today and which bear the notation, "Revised 11-30-62 TRW."

Also submitted with these plans at my request, were some construction specifications.

I believe it is now in order to issue the Permit and so recommend.

Very truly yours,

Roger C. Brown

Roger C. Brown

RCB:mmm

STATE OF CONNECTICUT

WATER RESOURCES COMMISSION
STATE OFFICE BUILDING - HARTFORD 15, CONNECTICUT

July 22, 1963

CONSTRUCTION PERMIT FOR DAM

Mr. Frank Butterworth, Jr.
Tuttle Avenue
Mt. Carmel, Connecticut

Dear Sir:

Your application for Construction Permit to construct a dam on Butterworth River in the Town of Hamden in accordance with the attached plans prepared by the Soil Conservation Service and revised on November 30, 1963, by Mr. [illegible]. R. Wire has been considered and the construction described therein is hereby approved only under the following conditions:

1. The Commission shall be notified

   A) When construction is started
   B) When foundation is excavated
   C) When the dam is completed and before water is impounded
   D) When project is completed and ready for final inspection

This permit, with the attached set of plans and specifications, must be kept at the site of the work and made available to the Commission at any time during the construction. This permit covers the construction as described in the attached documents. If any changes are contemplated, the Commission must be notified and supplementary approval obtained.

If the construction authorized by this construction permit is not started within two years of the date of this permit and completed within four years of the same date, this permit must be renewed.

Your attention is directed to Section 25-115 of the 1958 Revision of the General Statutes - "Liability of owner or operator. Nothing in this chapter and no order, approval or advice of the Commission or a member thereof, shall relieve any owner or operator of such a structure from his legal duties, obligations and liabilities resulting from such ownership or operation.

STATE OF CONNECTICU

WATER RESOURCES COMMISSIO

Mr. [illegible] Butterworth, STATE OFFICE BUILDING - HARTFORD 15, CONNECTICUT

July

No action for damages sustained through the partial or total i
of any structure or its maintenance shall be brought or maint
against the state, a member of the Commission or the Commissic
its employees or agents, by reason of supervision of such stru
exercised by the Commission under this chapter."

The Commission cannot convey or waive any property right
lands of the State, nor is this permit to be construed as givi
property rights in real estate or material or any exclusive pr
nor does it authorize any injury to private property or the in
of private rights or any infringement of federal, state or loc
or regulations.

Your attention is also directed to Section 26-134 of the
Revision of the General Statutes - "Obstructing Streams. No p
shall, unless authorized by the director, prevent the passing
in any stream or through the outlet or inlet of any pond or str
means of any rack, screen, weir or other obstruction or fail,
ten days after service upon him of a copy of an order issued by
Director, to remove such obstruction." The address of the Stat
of Fisheries and Game is State Office Building, Hartford, Conne

Very truly yours,

William S. Wise
Director

WSW:dlp
enc.

September 24, 1963

Mr. Roger C. Brown
Blair Associates
93 Whitney Avenue
New Haven, Connecticut

Dear Mr. Brown:

We have been notified that the Butterworth Dam in the Town of Hamden has been completed and is ready for final inspection.

Would you please inspect the dam and advise this office whether a Certificate of Approval should be issued to the owner.

Very truly yours,

William P. Sander
Engineer - Geologist

WPS:dlp

CLARENCE BLAIR ASSOCIATES

Civil and Sanitary Engineers

93 WHITNEY AVENUE
P. O. BOX 236
NEW HAVEN 2, CONNECTICUT

TEL. 777-7378

ROGER C. BROWN
JAMES C. BEACH
FRANK RAGAINI

CLARENCE M. BLAIR
(1904-1944)

CHARLES E. AUGUR, JR.
GORDON BILIDES
JOHN M. BREST
DONALD L. DISBROW
NICHOLAS PIPERAS, JR.

October 7, 1963

State Water Resources Commission
State Office Building
Hartford 15, Connecticut

Re: Butterworth Dam
Hamden, Connecticut

Attention: Mr. William P. Sander
Engineer - Geologist

Gentlemen:

In accordance with your letter of September 24, 1963 I inspected the subject dam on October 5.

The dam is completed except for final seeding of the embankment and this was being done on the day of my inspection.

Mr. Butterworth called me the other day and I told him that he could close the gates but this has not been done and no water has been impounded. I believe that it will be better procedure not to issue the final certificate of approval until the dam has been inspected when the pond is full of water. I also want to be certain that the top of the embankment is sodded over as the "vegetated spillway" is an important part of this dam.

Very truly yours,

Roger C. Brown

Roger C. Brown

Consulting Engineer

RCB:mr

1974 - Dam has been inspected + approved

APPENDIX C

DETAIL PHOTOGRAPHS

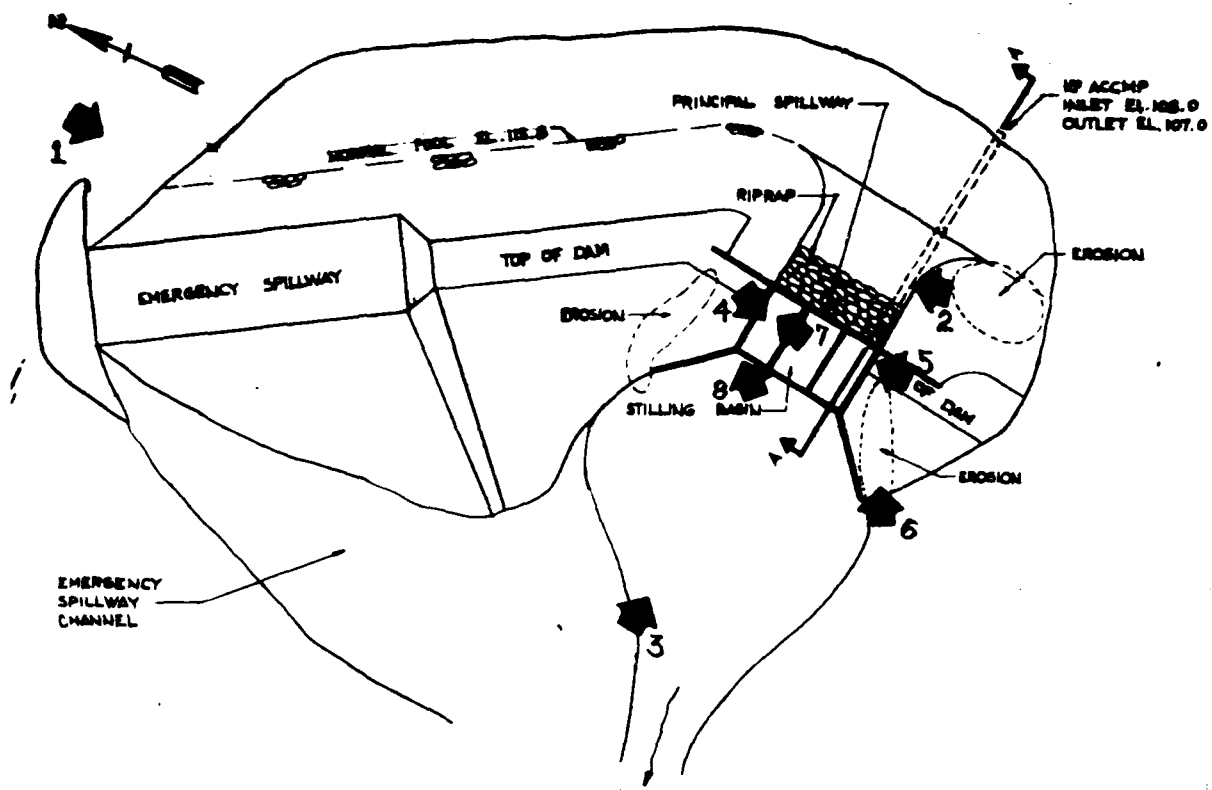


PHOTO NUMBER AND DIRECTION

PHOTO LOCATION PLAN

BUTTERWORTH POND DAM

SHEET C-1

Photo 1 - Upstream slope from right abutment (April, 1981).

Photo 2 - Top of dam from left side of principal spillway (April, 1981).

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS	NATIONAL PROGRAM OF	Butterworth Pond Dam Butterworth Brook Hamden, CT
CAHN ENGINEERS INC. WALLINGFORD, CONN ENGINEER	INSPECTION OF NON-FED. DAMS	CE # 27 785 KH DATE June 1981 PAGE C-1

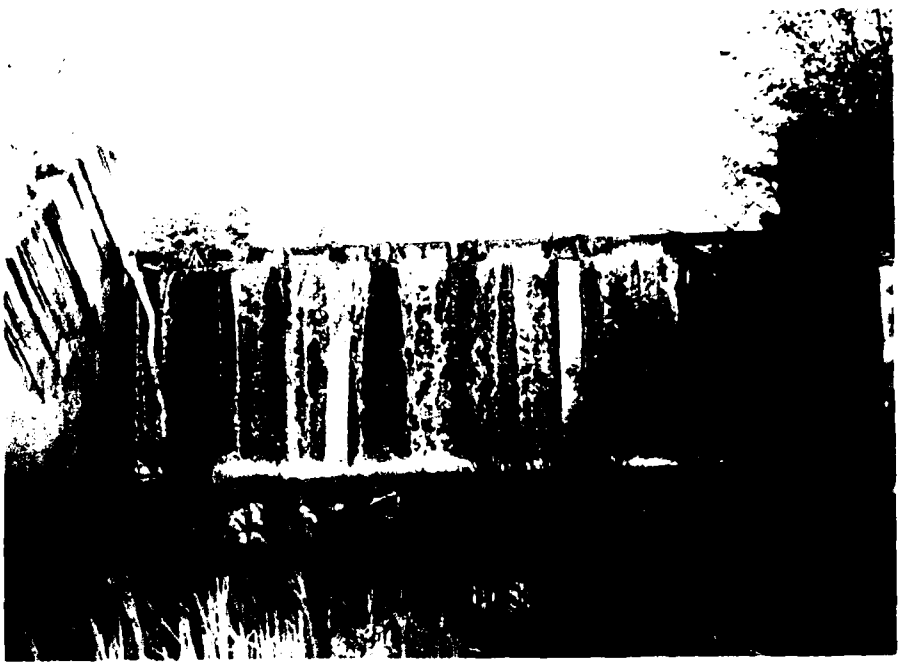


Photo 3 - Principal spillway from discharge channel (April, 1981).

Photo 4 - Stones piled up at downstream end of stilling basin. The outline of the sill, submerged by a foot of water, can be seen (April, 1981).

Photo 5 - Erosion and missing fill at left side of principal spillway in auxiliary overflow area (April, 1981).

Photo 6 - Erosion on downstream slope at left side of principal spillway in auxiliary overflow area (April, 1981).

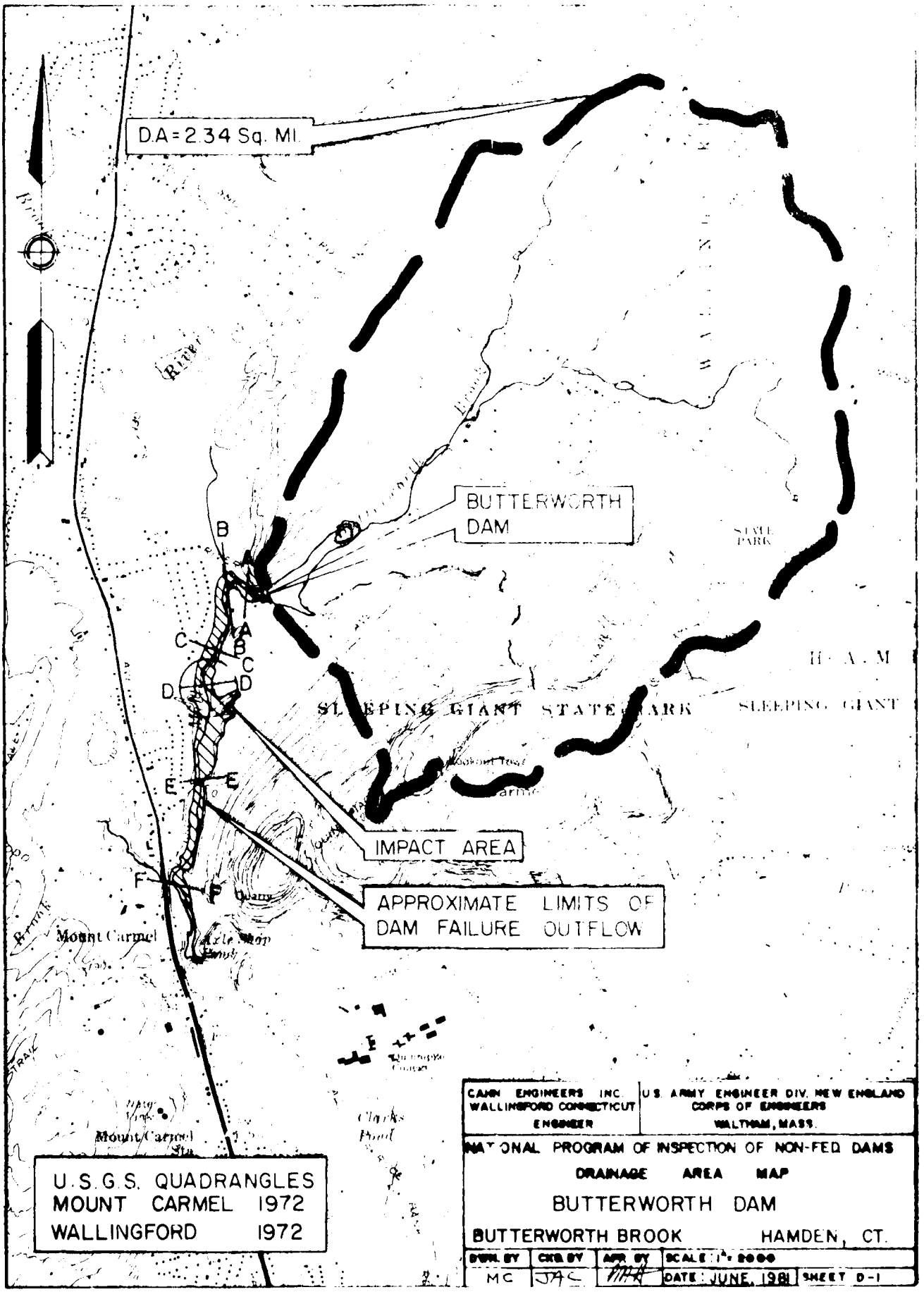
Photo 7 - Crack in right principal spillway training wall. Crack measures 3 feet long by 2 inches deep (April, 1981).

Photo 8 - 3 inch diameter hole in right training wall at principal spillway (April, 1981).

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.	NATIONAL PROGRAM OF	Butterworth Pond Dam Butterworth Brook Hamden, CT
CAHN ENGINEERS INC. WALLINGFORD, CONN. ENGINEER	INSPECTION OF NON-FED. DAMS	CE # 27 785 KH DATE June 1981 PAGE C-4

APPENDIX D

HYDRAULICS/HYDROLOGIC COMPUTATIONS


D.A = 2.34 Sq. MI.
BUTTERWORTH DAM
IMPACT AREA
APPROXIMATE LIMITS OF DAM FAILURE OUTFLOW
SLEEPING GIANT STATE PARK
SLEEPING GIANT
Mount Carmel
Mount Carmel Sta.
Clarks Pond
U.S.G.S. QUADRANGLES
MOUNT CARMEL 1972
WALLINGFORD 1972
CAHN ENGINEERS INC.
WALLINGFORD CONNECTICUT
ENGINEER
U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS
DRAINAGE AREA MAP
BUTTERWORTH DAM
BUTTERWORTH BROOK HAMDEN, CT.
DWN BY MC
CKD BY JAC
APP BY
SCALE 1" = 2000
DATE: JUNE, 1981
SHEET D-1

PERFORMANCE AT PEAK FLOOD CONDITIONS

PROBABLE MAXIMUM FLOOD (PMF) DETERMINATION –

DRAINAGE AREA – 2.34 SQ. M PLANIMETERED FROM MOUNT CARMEL QUADRANGLE SHEET (REV. 1972)

WATERSHED CLASSIFICATION – "ROLLING" TO "MOUNTAINOUS" BASED UPON USGS MAP AND SITE VISIT; CONSIDERABLE PORTION BEING EXTREMELY STEEP & ROCKY TERRAIN.

PMF PEAK INFLOW –

FROM THE CORPS OF ENGINEERS DECEMBER 1977 PEAK FLOW RATE GUIDE CURVES AN INTENSITY IN BETWEEN "ROLLING" AND "MOUNTAINOUS" TERRAIN FOR 2.34 SQ. M. IS SELECTED.

THE SELECTED INTENSITY = 2250 CFS/SQ. M

∴ PMF PEAK INFLOW = 2250 × 2.34 = 5265 CFS

SIZE CLASSIFICATION –

FOR THE PURPOSE OF DETERMINING PROJECT SIZE, THE MAXIMUM STORAGE ELEVATION IS CONSIDERED EQUAL TO THE TOP OF DAM

TOP OF DAM EL = 121 NGVD*
TOE OF DAM EL = 106 NGVD (CHANNEL BED)
HEIGHT OF DAM = 15 FT

* THE W.S. ELEVATION IS ASSUMED TO BE THE SPILLWAY CREST ELEVATION OF 115.75 (115 + 0.75' OF STEEL PLATE) ON NATIONAL GEODETIC VERTICAL DATUM (NGVD) PER THE DESIGN DRAWINGS (REVISED NOV. 30, 1962) PREPARED BY SOIL CONSERVATION SERVICE. ALL OTHER ELEVATIONS ARE REFERENCED TO THIS ASSUMED ELEVATION.

PLANIMETERING FROM USGS MAP FOR POND SURFACE AREAS

AT EL 115.75 (SPILLWAY CREST) = 10 ACRES
AT EL 120 = 18 ACRES
AT EL 121 (TOP OF DAM) = 20 ACRES

A STAGE-POND AREA CURVE IS PLOTTED (SHEET 3)

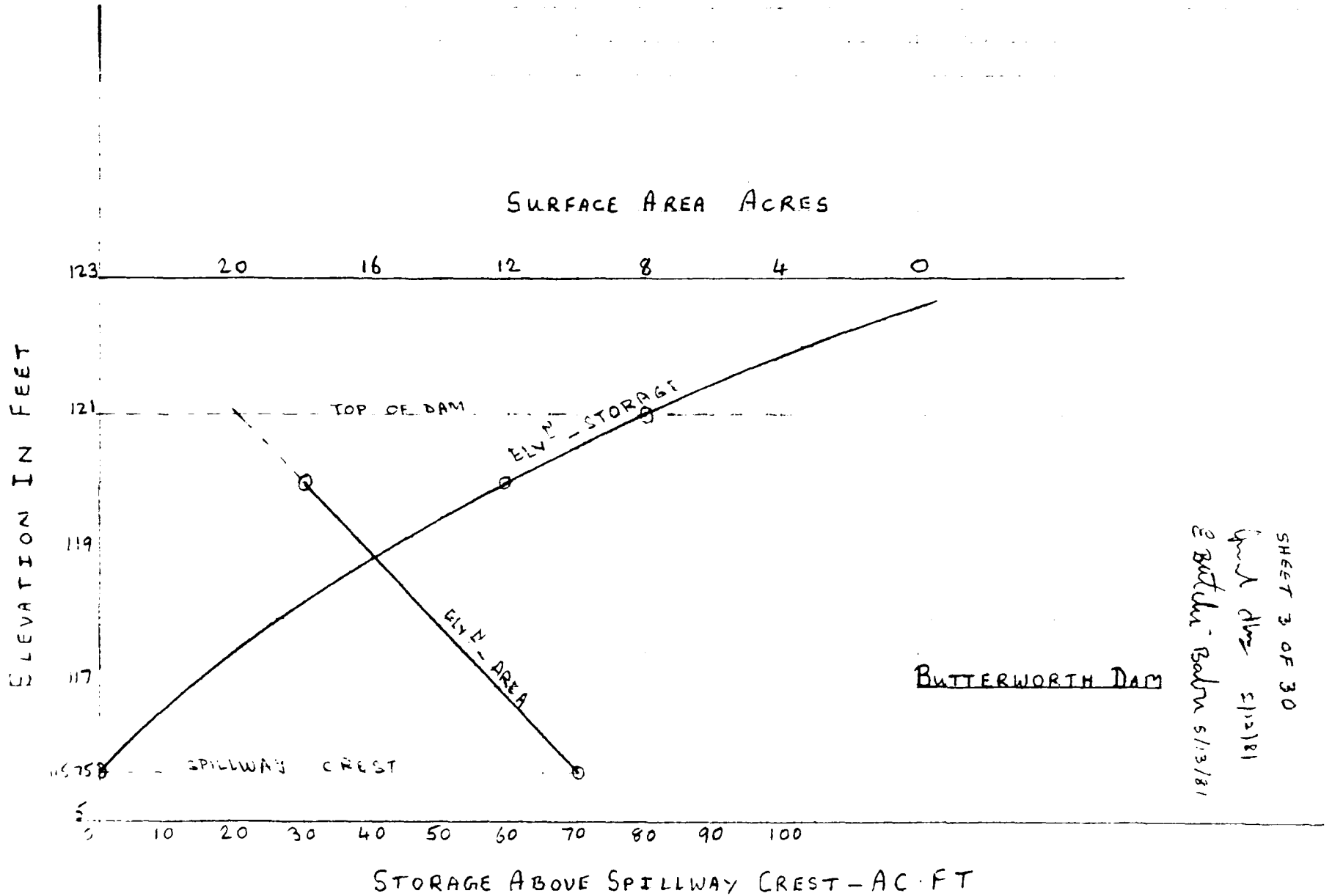
AVERAGE POND AREA BETWEEN SPILLWAY CREST AND TOP OF DAM $= \frac{10+20}{2} = 15$ AC. FT.

STORAGE BETWEEN SPILLWAY CREST AND TOP OF DAM $= 15 \times 5.25 \cong \underline{80}$ AC. FT.

ESTIMATED STORAGE BELOW SPILLWAY CREST $= \frac{1}{3} \times 10 \times (115.75 - 106)$
$= 33$ AC. FT.

∴ MAXIMUM IMPOUNDMENT TO TOP OF DAM $= 80 + 33 = \underline{113}$ AC. FT.

A STAGE-STORAGE CURVE IS PLOTTED ON SHEET 3 THUS, ACCORDING TO CORPS OF ENGINEERS GUIDELINES TABLE 1, THE BUTTERWORTH DAM IS CLASSIFIED SMALL BASED UPON THE STORAGE CAPACITY OF 113 AC. FT (< 1000 AND ≥ 50) AND HEIGHT OF THE DAM IS ONLY 15'.



BUTTERWORTH DAM

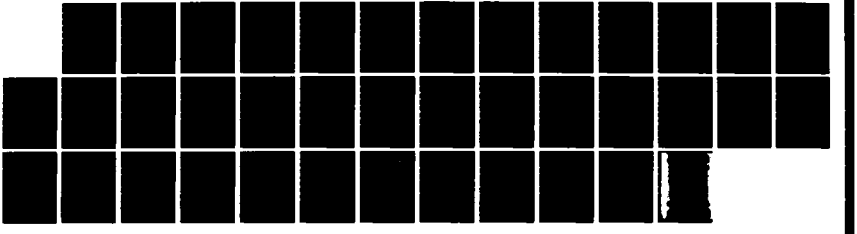
SHEET 3 OF 30

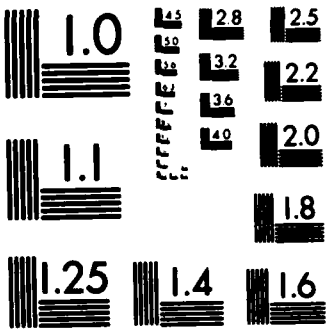
Hunt dam 5/12/81

& Butler Basin 5/13/81

AD-A143 046 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 2/2
BUTTERWORTH DAM (CT 0.. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV JUN 81

UNCLASSIFIED F/G 13/13 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

HAZARD POTENTIAL — SIGNIFICANT HAZARD POTENTIAL BASED UPON DAM BREACH ANALYSIS AND RELATIVE LOCATION OF THE SLEEPING GIANT GOLF COURSE. A DETAILED DISCUSSION OF HAZARD POTENTIAL IS INCLUDED AT THE END OF BREACH ANALYSIS SECTION OF APPENDIX D.

SELECTION OF TEST FLOOD—
FOR THE SMALL SIZE AND SIGNIFICANT HAZARD POTENTIAL CLASSIFICATION. TABLE 3 OF CORPS OF ENGINEERS RECOMMENDED GUIDELINES, THE TEST FLOOD COULD BE IN THE 100 YEAR TO $\frac{1}{2}$ PMF RANGE.

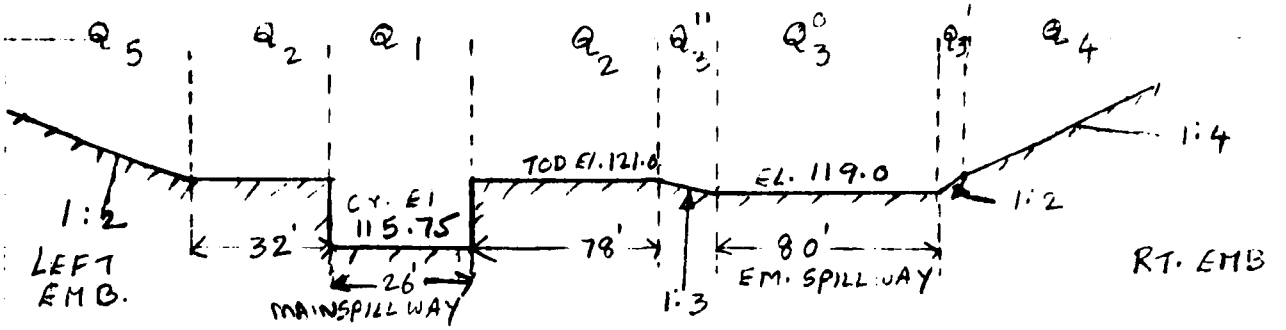
BASED UPON THE INVOLVED RISK POTENTIAL DOWNSTREAM OF THE DAM, A TEST FLOOD = 100 YR IS SELECTED (LOW END OF THE RANGE).

$\therefore$ TEST FLOOD PEAK INFLOW = $\frac{5''}{19''} \times 5265$

= 1400 CFS

NOTE: PMF OF 5265 CFS IS ESTIMATED TO RESULT FROM 19" RUN-OFF AND A 100 YEAR FLOOD IN CONNECTICUT IS ESTIMATED TO RESULT FROM APPROXIMATELY 5" RUN-OFF.

COMPOSITE DISCHARGE RATING CURVE



APPROXIMATE POTENTIAL OVERFLOW PROFILE
BASED ON DESIGN DRAWINGS & FIELD OBSERVATIONS
(LOOKING D/S)

SPILLWAY — RECTANGULAR DROP SPILLWAY

$Q_1 = 3.1 L H^{3/2}$ REF: HANDBOOK OF APPLIED HYDROLOGY BY VEN TE CHOW, P. 21-62

$= 80.6 H^{3/2}$ FOR Cr. El = 115.75, L = 26'

DAM —

$Q_2 = C L H^{3/2}$ C = 2.8 ASSUMED (Earth)

$= 308 H^{3/2}$ L = 78 + 32 = 110 FT.

Cr. El = 121.0

EMERGENCY SPILLWAY —

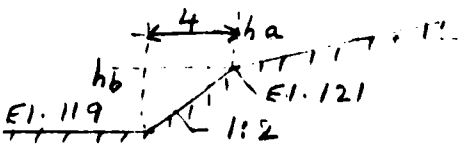
$Q^0_3 = C L H^{3/2}$ C = 2.8 ASSUMED

$= 224 H^{3/2}$ L = 80' Cr. El 119

$Q'_3 = \frac{2}{5} \frac{CL}{(h_1 - h_a)} (h_b^{5/2} - h_a^{5/2})$ *

$= 0.4 \times 2.8 \times 2 \times h_b^{5/2}$

$= 2.24 h_b^{5/2}$ UPTO El. 121



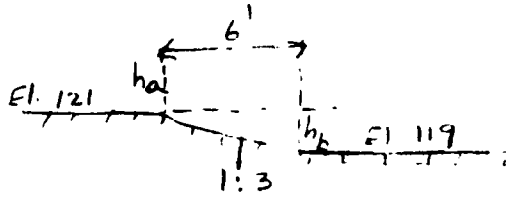
ha = 0 UPTO El 121

* USGS recommended formula for more precise discharge over inclined Dam/Embankment Crest (Ref: Measurement of Peak discharges at dam by indirect methods, USGS Book-3, Chapter A-5, Page 3-4, 1968)

$$Q''_3 = \frac{2}{5} \frac{CL}{(h_b - h_a)} \left(h_b^{5/2} - h_a^{5/2}\right)$$

$$= \frac{3.36\, h_b^{5/2}}{} \text{ upto El. } 121.0$$

$$Q_3 = Q^{\circ}_3 + Q'_3 + Q''_3$$



RIGHT EMBANKMENT

$$Q_4 = \frac{2}{5} \frac{CL}{(h_b - h_a)} \left(h_b^{5/2} - h_a^{5/2}\right)$$

ASSUME C = 2.5

$$= \underline{4\, h_b^{5/2}}$$

LEFT EMBANKMENT

SIMILARLY

ASSUME C = 2.5

$$Q_5 = \underline{2\, h_b^{5/2}}$$

OUTLET

DRAINPIPE 18" ACCMP USED 18" PIPE

OUTLET ELEVATION = 107 CL 107.75 / 107

$$Q_6 = C A \sqrt{2gH}$$

$$= \underline{14.2\, H^{1/2}} \quad \text{NEGLECTING LOSSES}$$

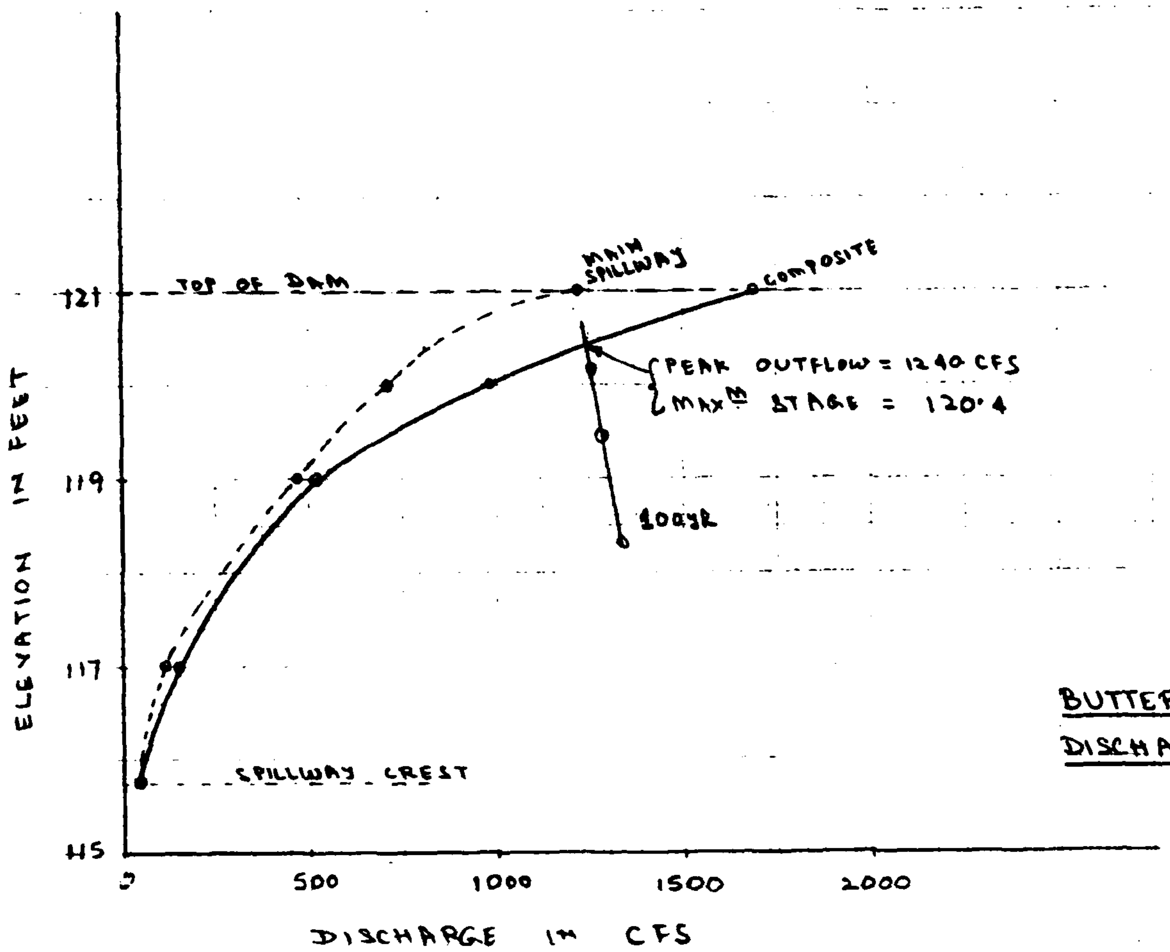
FOR POOL AT TOD (El. 121) Q_6 = 52 CFS

TABULATION OF DISCHARGE RATES (CFS)

	ELVN NGVD	SP.WAY Q_1	DAM Q_2	EMERGENCY SPILLWAY Q^0_3	Q^1_3	Q''_3	Q_3	RIGHT EMB. Q_4	LEFT EMB Q_5	OUTLET Q_6	TOTAL Q
SP. CV	115.75	0	0	0	0	0	0	0	0	40	40
	117	113	0	0	0	0	0	0	0	43	156
	119	472	0	0	0	0	0	0	0	48	520
	120	706	0	224	2	3	229	0	0	50	985
TEST FLOOD	120.4	810	0	366	5	8	379	0	0	51	1240
TOD	121	970	0	634	12	19	665	0	0	52	1687

DISCHARGE RATING CURVES FOR TOTAL Q (COMPOSITE) AND SPILLWAY ARE PLOTTED ON NEXT SHEET.

5/12/81
5/13/81



BUTTERWORTH DAM
DISCHARGE RATING CURVES

PROJECT NON FEDERAL DAM INSPECTION — PROJECT NO. 80-20-10 — SHEET 9 OF 30
NEW ENGLAND DIVISION — COMPUTED BY [illegible] — DATE 5/12/81
BUTTERWORTH DAM — CHECKED BY E. Butterworth Baker — DATE 5/13/81

DETERMINATION OF PEAK OUTFLOW —
SHORT CUT ROUTING OF POND
CORPS OF ENGINEERS GUIDELINES "SURCHARGE STORAGE ROUTING" ALTERNATIVE METHOD USED.
FOR 1400 CFS (100 YR) THE DISCHARGE RATING CURVE GIVES ELVN = 120.62

AND FROM STAGE-STORAGE CURVE FOR THIS ELVN
STORAGE = 72 AC.FT.

$STOR_i = \frac{72 \times 12}{2.34 \times 640} = 0.58''$ RUN-OFF

$QP_i = QP_1 \left(1 - \frac{STOR_i}{5}\right)$

① $STOR_i$ INCHES	② $\left(1 - \frac{STOR_i}{5}\right)$	③ $STOR_i$ AC.FT. ① $\times \frac{2.34 \times 640}{12}$	④ QP_i CFS ② $\times$ 1400	⑤ ELVN FROM STORAGE CURVE USING ③
0.25	.95	31.2	1330	118.3
0.4	.92	49.92	1288	119.45
0.5	.90	62.4	1260	120.15

COLUMNS ④ & ⑤ ARE PLOTTED ON DISCHARGE RATING CURVE AND

PEAK OUTFLOW Q = 1240 CFS

MAXIMUM STAGE = 120.4
TOP OF DAM = 121

∴ THE DAM IS NOT OVERTOPPED

BREACH ANALYSIS - DOWNSTREAM FAILURE HAZARD

BASED UPON CORPS OF ENGINEERS "RULE OF THUMB" GUIDANCE FOR ESTIMATING D/S DAM FAILURE HYDROGRAPHS

BREACH OUTFLOW $Q_b = \frac{8}{27} \times W_b \times \sqrt{g} \times Y_o^{3/2}$

HEIGHT FROM CHANNEL BED TO POOL @ TOP OF DAM
$Y_o = 15$ FT

ESTIMATED BREACH WIDTH W_b = 40% OF MID-HT LENGTH OF DAM = $0.4 \times 170' = 68'$

(MID HEIGHT LENGTH IS BASED UPON CAHN ENGINEERS FIELD INFORMATION)

$\therefore Q_b = \frac{8}{27} \times 68 \times \sqrt{32.2} \times (15)^{3/2} \cong 6640$ CFS

IT IS PRESUMED THAT THE BREACH OCCURS IN DEEPEST SECTION OF THE DAM. THIS SECTION INCLUDES THE SPILLWAY ESTIMATED DISCHARGE THROUGH EMERGENCY SPILLWAY AT THE TOP OF THE DAM = 665 CFS

$\therefore$ PEAK FAILURE OUTFLOW $Q_{P_1} = 6640 + 665 \cong 7,300$ CFS

ESTIMATED FAILURE FLOOD DEPTH $\cong 0.44\, Y_o$

IMMEDIATELY D/S FROM DAM $\cong 6.6$ FT

PERFORM D/S ROUTING OF PEAK FAILURE OUTFLOW

SECTION AA IS SELECTED AT 260' D/S OF THE DAM

DISTANCE TO BRIDGE = 520' PER USGS MAP.

USING MANNING'S EQUATION

$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$ WHERE $n = 0.06$ ASSUMED (Stones Brush)

$= \frac{1.76}{n} A R^{2/3}$ $S = 0.005$ (Based upon Existing Design Drawings)

A AND R ARE ESTIMATED BASED UPON FIELD DATA AND USGS MAP INFORMATION

ELVN	A-SQ-FT	P	R	$R^{2/3}$	Q CFS
105	0	—	—	—	—
108	275	182.7	1.505	1.314	636
110	750	300.3	2.498	1.841	2430
112	1375	325.8	4.22	2.613	6323
113	1706	338.1	5.046	2.943	8837

FROM STAGE-AREA AND STAGE DISCHARGE CURVES.

FOR QP_1 = 7,300 CFS. ELVN = 112.4. AREA = 1506 SQ·FT

VOLUME OF REACH $V_1 = \frac{520 \times 1506}{43,560} = 18$ AC·FT

TRIAL $QP_2 = QP_1 (1 - \frac{V_1}{S}) = 7300 (1 - \frac{18}{113}) = 6,140$ CFS

FOR THIS QP_2 THE STAGE-DISCHARGE CURVE GIVES ELVN = 111.9 AND AREA = 1343 SQ·FT

VOLUME OF REACH $V_2 = \frac{520 \times 1343}{43,560} = 16$ AC·FT

RECOMPUTING $QP_2 = 7300 \left(1 - \frac{\frac{16+18}{2}}{113}\right) \cong 6,210$ CFS

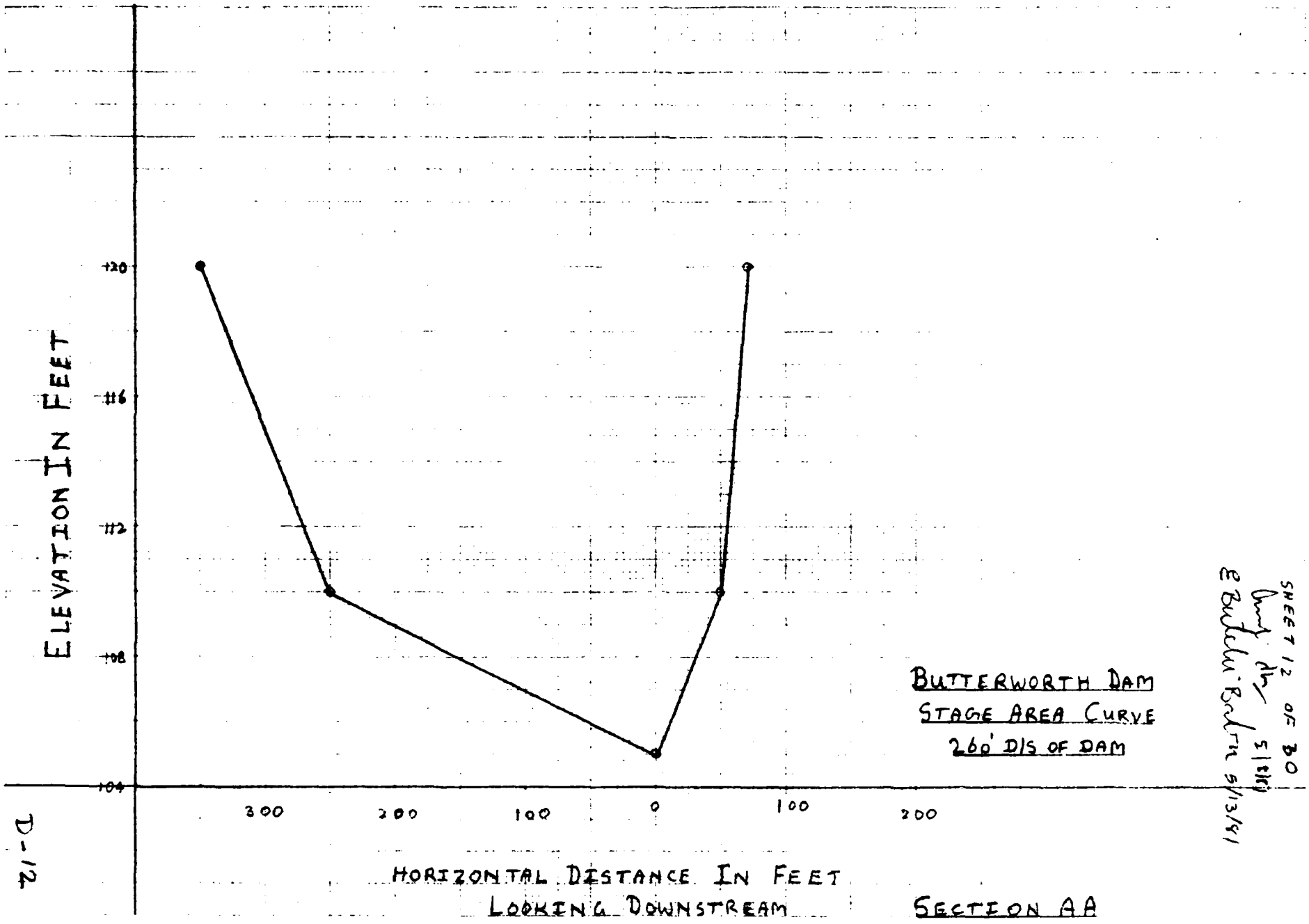
PEAK OUTFLOW QP_2 = 6,210 CFS

FLOOD STAGE AT BRIDGE = 111.9 NGVD

FLOOD DEPTH AT BRIDGE = 111.9 − 105 = 6.9 FT

VELOCITY AT BRIDGE $= \frac{6210}{1343} = 4.6$ FPS

AT THE CULVERT, THE ROAD SURFACE IS 7'± ABOVE CHANNEL BED.

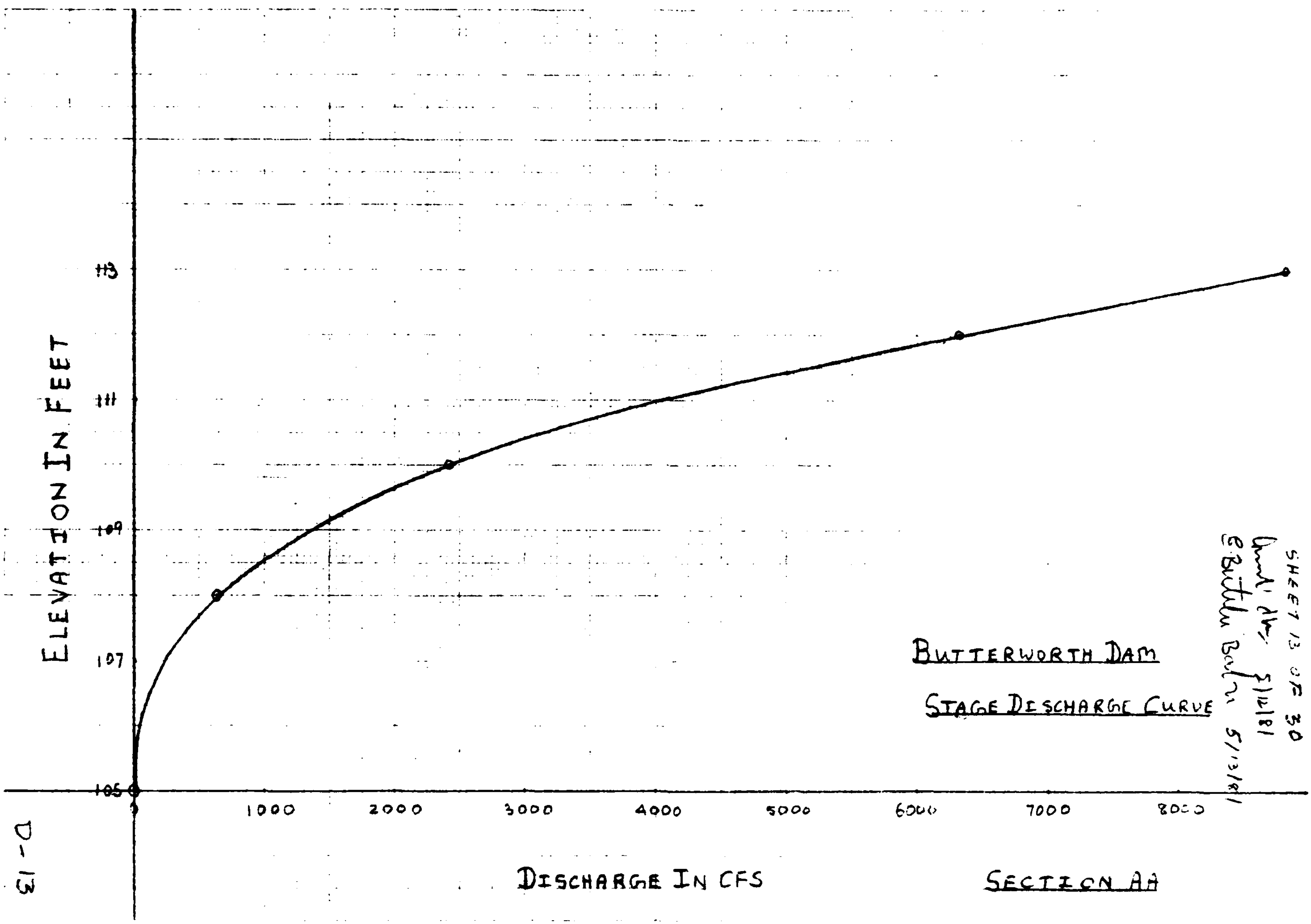


BUTTERWORTH DAM
STAGE AREA CURVE
260' D/S OF DAM

SECTION AA

SHEET 12 OF 30
Survey dtm
E Buffalo Bottom 5/13/91

SHEET 13 OF 30



SELECTING A SECTION BB 100' D/S OF BRIDGE

$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$ Where $n = 0.05$ Assumed
$= 2.11 AR^{2/3}$ $S = 0.005$ Estimated

EL	A Sq. Ft.	P	R	$R^{2/3}$	Q CFS
102.8	0	—	—	—	—
104	84	140	0.6	0.711	126
106	592	370.1	1.6	1.368	1709
108	1565	602.1	2.6	1.89	6245

STAGE AREA AND STAGE DISCHARGE CURVES ARE PLOTTED FOR $QP_1 = 6210$ CFS, ELVN = 108, AND AREA = 1565 □'
VOLUME OF REACH $V_1 = \frac{100 \times 1565}{43,560} = 3.6$ Ac. Ft.

TRIAL $QP_2 = QP_1\left(1 - \frac{V_1}{S}\right) = 6210\left(1 - \frac{3.6}{113}\right) \cong 6015$ CFS
FOR 6015 CFS, ELVN = 107.9 AND AREA = 1505 □'

$V_2 = \frac{100 \times 1505}{43,560} = 3.5$ Ac. Ft

RECOMPUTING $Q_{1/2} = 6210\left(1 - \frac{3.6+3.5}{2} \over 113\right) \cong$ 6015 CFS

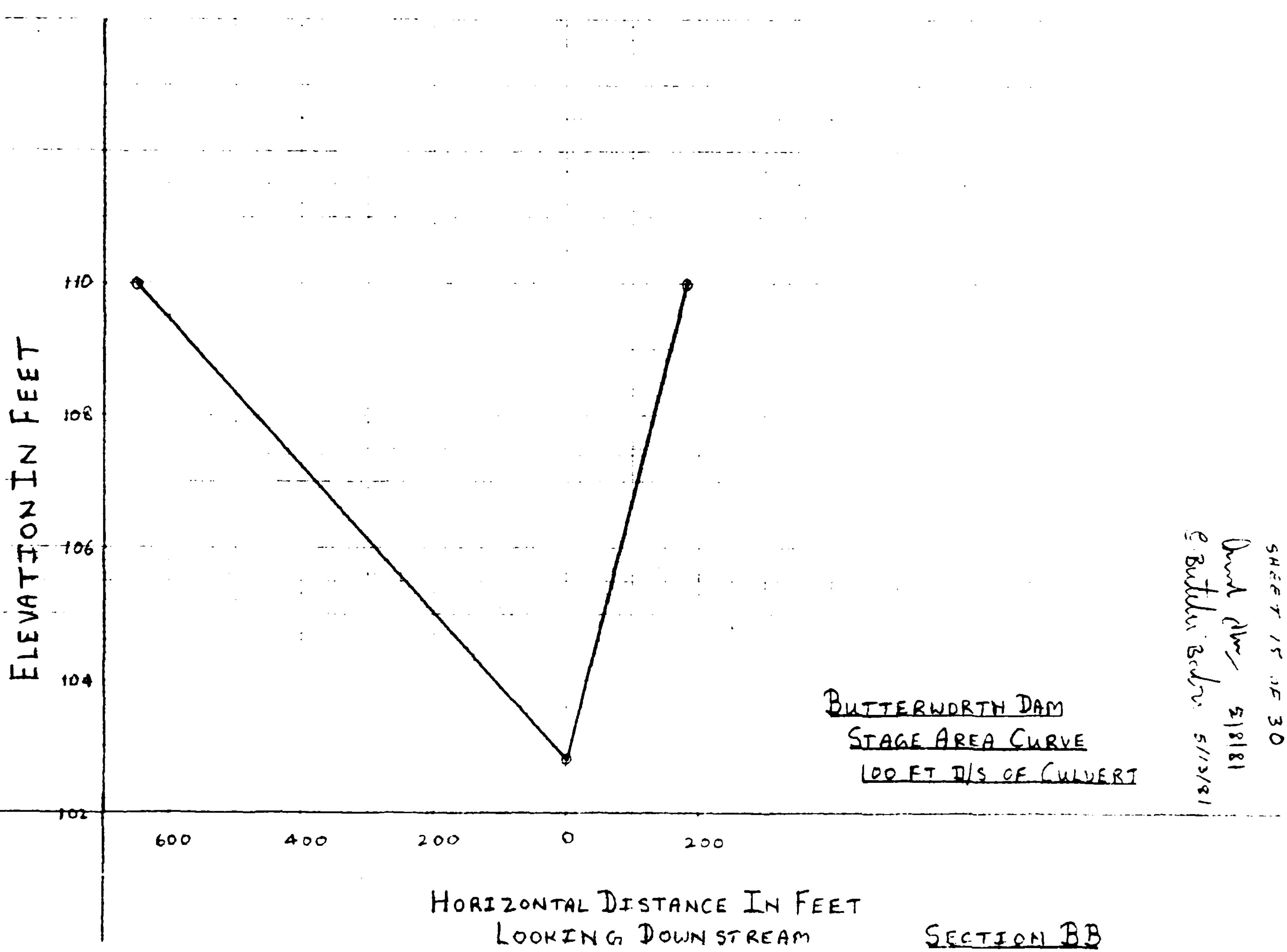
FLOOD STAGE AT SECTION BB = 107.9 NGVD

FLOOD DEPTH AT SECTION BB = 107.9 − 102.8 = 5.1 FT

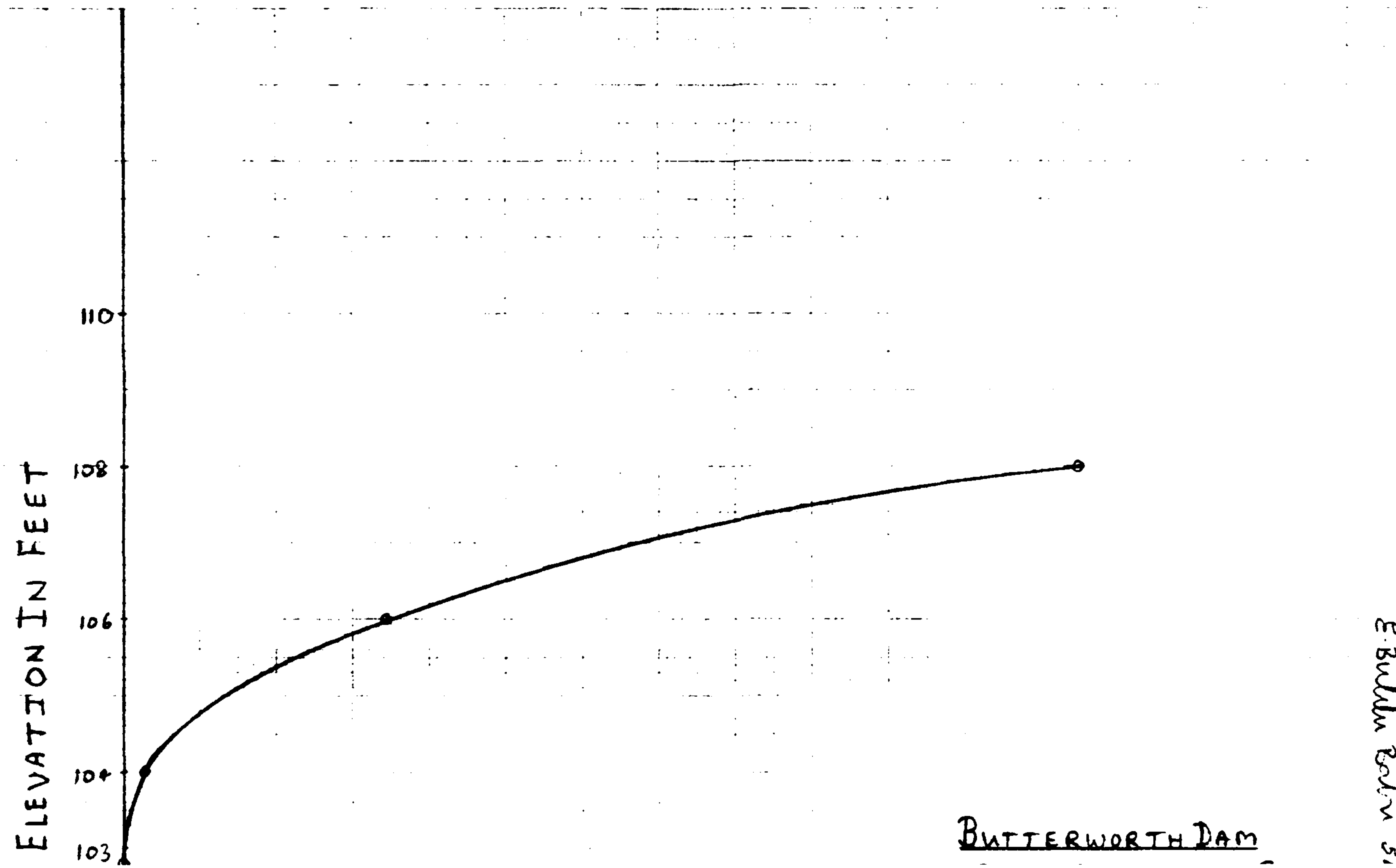
VELOCITY AT SECTION BB = $\frac{6015}{1505} \cong 4$ FPS
PEAK OUTFLOW QP_2 = 6015 CFS

THE GROUND FLOOR OF THE RANCH HOUSE IS 7+ FT. ABOVE THE STREAM BED. THEREFORE, THIS HOUSE WILL NOT BE AFFECTED. THE HOUSES ON MacARTHUR DRIVE TO MILL RIVER AT ITS CONFLUENCE WITH BUTTERWORTH BROOK ARE 12+ FT. ABOVE STREAM BED.

SHEET 15 OF 30



SECTION BB


ELEVATION IN FEET
110
108
106
104
103
BUTTERWORTH DAM

SELECT A SECTION CC 1000' D/S OF SECTION BB

$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$ Where $n = 0.05$ Assumed
$S = 0.003$ Est. from USGS map

$= 1.628\ A R^{2/3}$

EL.	Asq·Ft	P	R	$R^{2/3}$	Q
100	0	—	—	—	0
102	77.5	77.6	1	1	126
104	306	153.3	1.996	1.586	790
107	934.5	267.5	3.493	2.303	3504
110	1900	380.7	4.99	2.922	9038

STAGE AREA AND STAGE DISCHARGE CURVES ARE PLOTTED FOR QP_1 = 6015 CFS. ELVN = 108.8 AND AREA = 1465 □'
VOLUME OF REACH $V_1 = \frac{1000 \times 1465}{43,560} = 33.6$ AC·FT

TRIAL $QP_2 = QP_1 \left(1 - \frac{V_1}{S}\right) = 6015 \left(1 - \frac{33.6}{113}\right) \cong 4230$ CFS

FOR 4230 CFS. ELVN = 107.6 AND AREA = 1106 SQ·FT

$\therefore V_2 = \frac{1000 \times 1106}{43,560} = 25$ AC·FT

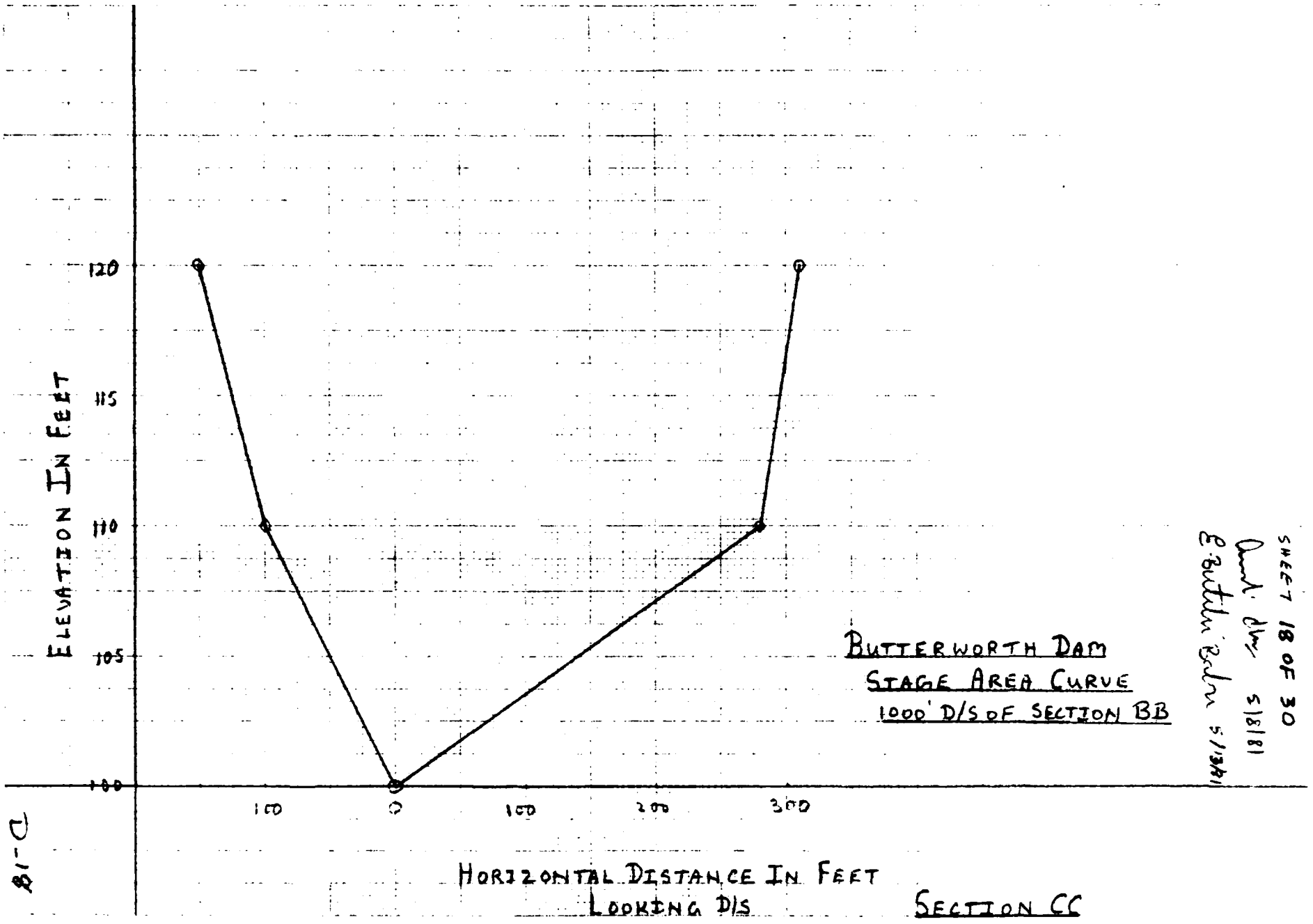
RECOMPUTING $QP_2 = 6015 \left(1 - \frac{\frac{33.6+25}{2}}{113}\right) = 4460$ CFS

FLOOD STAGE = 107.8 NGVD

DEPTH OF FLOODWATER AT SECTION CC = 107.8 − 100 = 7.8 FT

VELOCITY AT SECTION CC $= \frac{4460}{1166} = 3.8$ FPS

PEAK OUTFLOW QP_2 = 4460 CFS

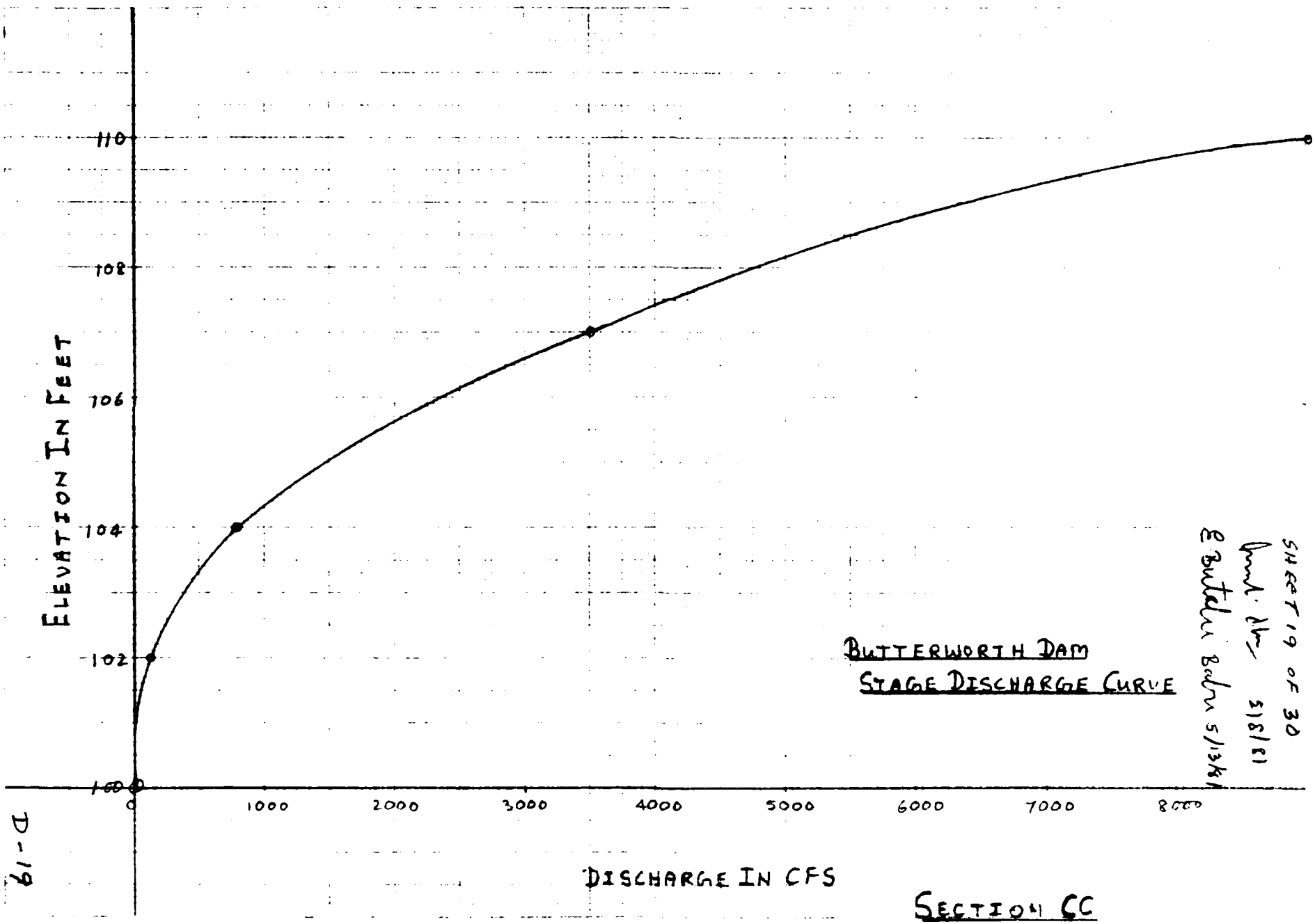


BUTTERWORTH DAM
STAGE AREA CURVE
1000' D/S OF SECTION BB

SECTION CC

SHEET 18 OF 30
Quad. dwg 5/18/81
E. Butler Eden 5/13/81

81-C



BUTTERWORTH DAM
STAGE DISCHARGE CURVE

SHEET 19 OF 30
Mark Abr 5/8/81
E Butler Baker 5/13/81

SECTION CC

SELECT A SECTION DD 600' D/S OF SECTION CC (GOLF COURSE)

$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$ Where $n = 0.045$ ASSUMED

$= 1.81\, A\, R^{2/3}$ $S = 0.0025$ Est from USGS MAP

EL	A Sq.Ft	P	R	$R^{2/3}$	Q CFS
98.2	0	—	—	—	0
100	63	70.1	0.9	0.932	106
103	424.5	171.3	2.478	1.832	1407
105	831.5	236.5	3.52	2.315	3484
106	1084.5	270.6	4.01	2.525	4957

STAGE AREA AND STAGE DISCHARGE CURVES ARE PLOTTED.

FOR $QP_1 = 4460$ CFS, ELVN = 105.7 AND AREA = 1005 Sq FT

VOLUME OF REACH $V_1 = \frac{600 \times 1005}{43,560} = 13.84$ Ac.FT

TRIAL $QP_2 = QP_1 \left(1 - \frac{V_1}{S}\right) = 4,460 \left(1 - \frac{13.84}{113}\right) \cong 3920$ CFS

FOR 3920 CFS, ELVN = 105.3 AND AREA = 904 Sq.Ft

$.1\, V_2 = \frac{600 \times 904}{43.560} = 12.5$ Ac.Ft.

RECOMPUTING $QP_2 = 4,460 \left(1 - \frac{13.84 + 12.5}{\frac{2}{113}}\right) \cong 3940$ CFS

FLOOD STAGE = 105.3 NGVD

DEPTH OF FLOOD WATER AT SECTION DD = 105.3 − 98.2 = 7.1 FT.

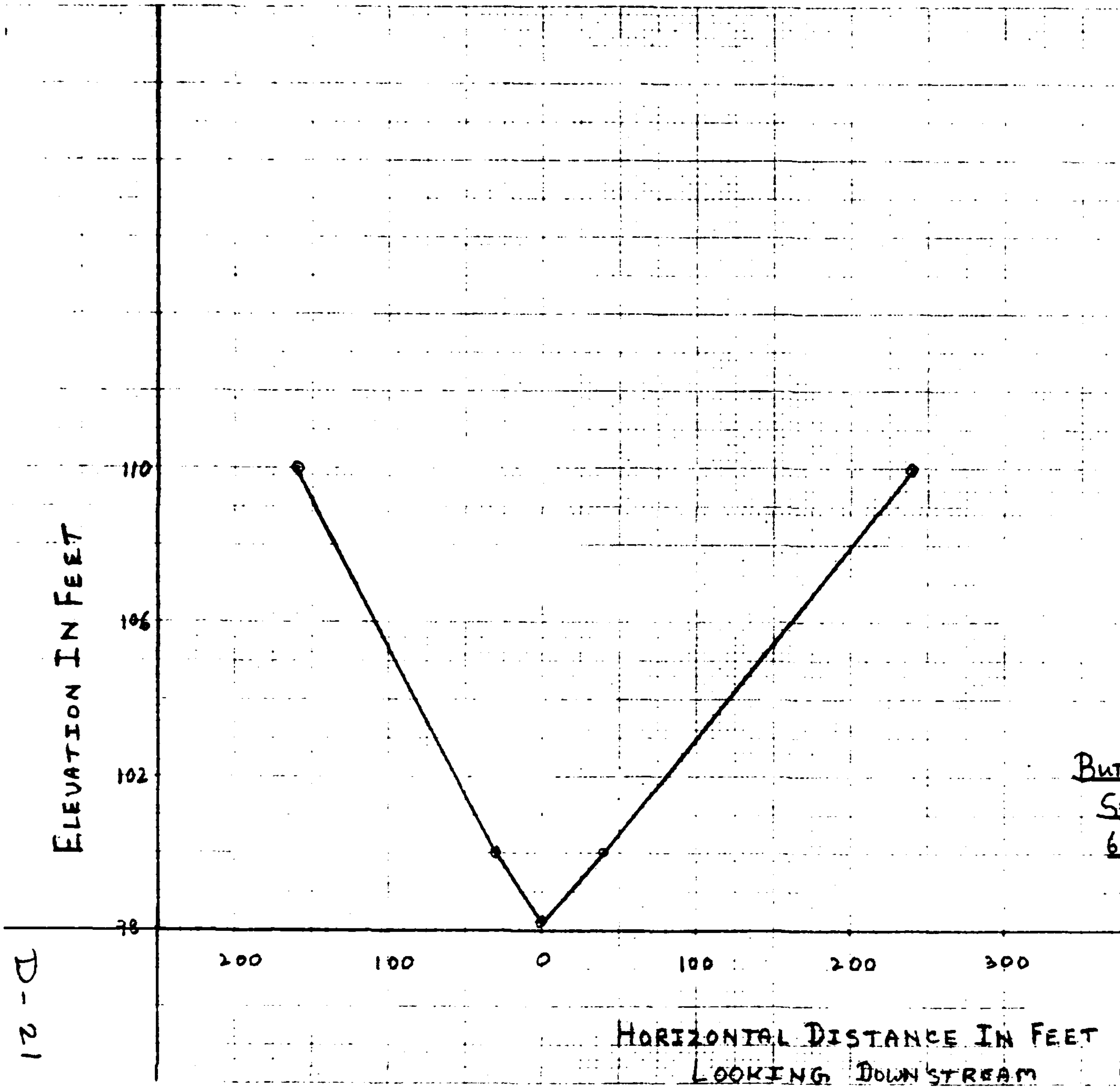
VELOCITY AT SECTION DD $= \frac{3940}{904} \cong 4.4$ FPS

PEAK OUTFLOW QP_2 = 3940 CFS

5/8/81

5/13/81

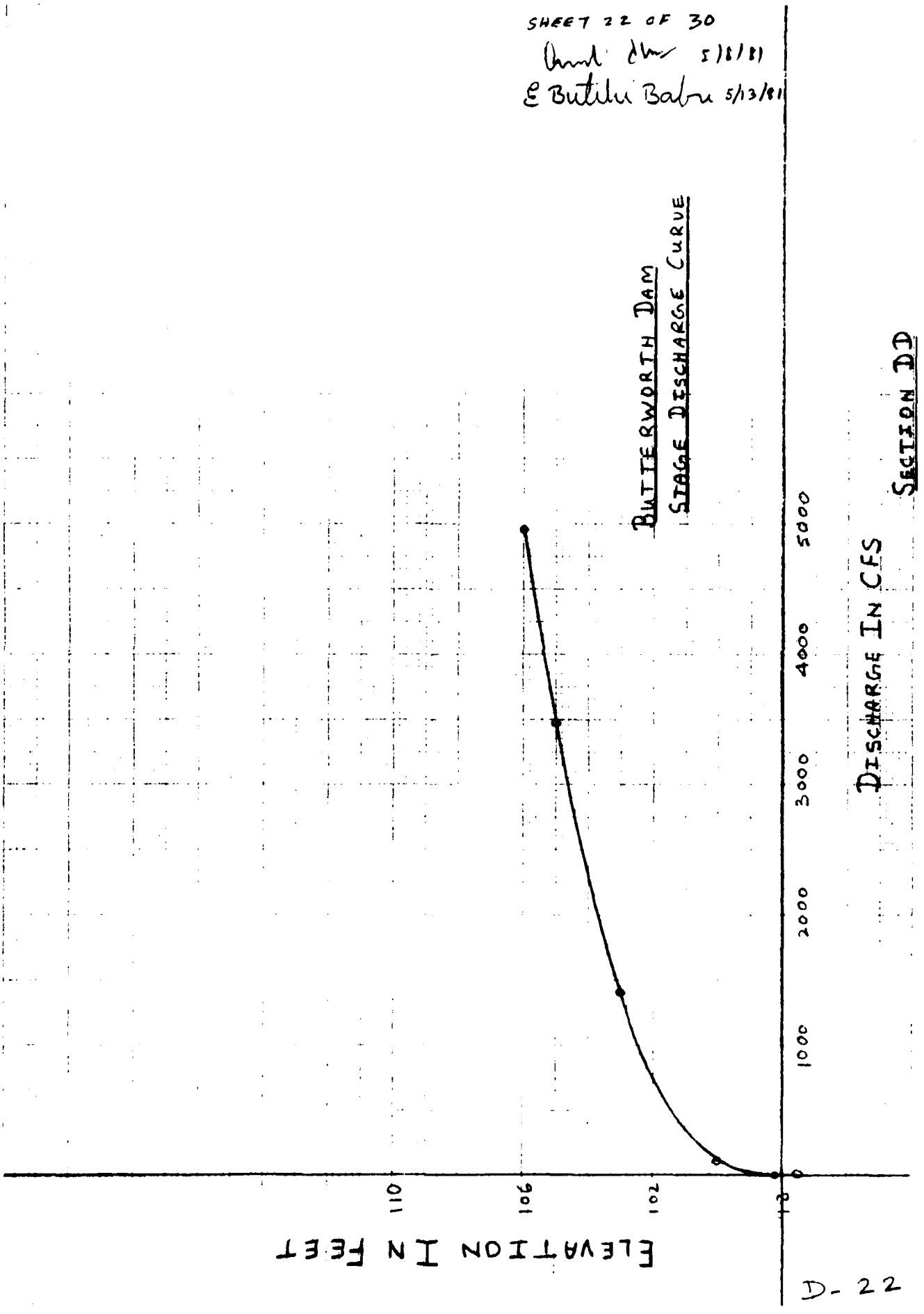
BUTTERWORTH DAM
STAGE AREA CURVE
600' D/S OF SECTION CC



SECTION DD

5/8/81

E Butiku Babu 5/13/81



SELECT A SECTION EE 1500' D/S OF SECTION DD (TUTTLE AVE. BRIDGE)

$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$ where $n = 0.045$ as NGD
$S = 0.0025$ EST. FROM USGS MAP
$= 1.81\ AR^{2/3}$

EL	A Sq. Ft	P	R	$R^{2/3}$	Q CFS
93.7	0	—	—	—	0
95	45	70	0.64	0.74	60
97	280	170	1.65	1.4	710
99	725	273	2.65	1.91	2510
100	1025	325	3.15	2.15	3990

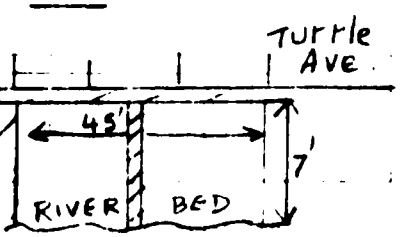
STAGE AREA AND STAGE DISCHARGE CURVES ARE PLOTTED FOR $Q_{P_1} = 3940$ CFS, ELVN = 99.9 AND AREA = 976 Sq. FT.
VOLUME OF REACH $V_1 = \frac{1500 \times 976}{43,560} = 33.6$ Ac. FT

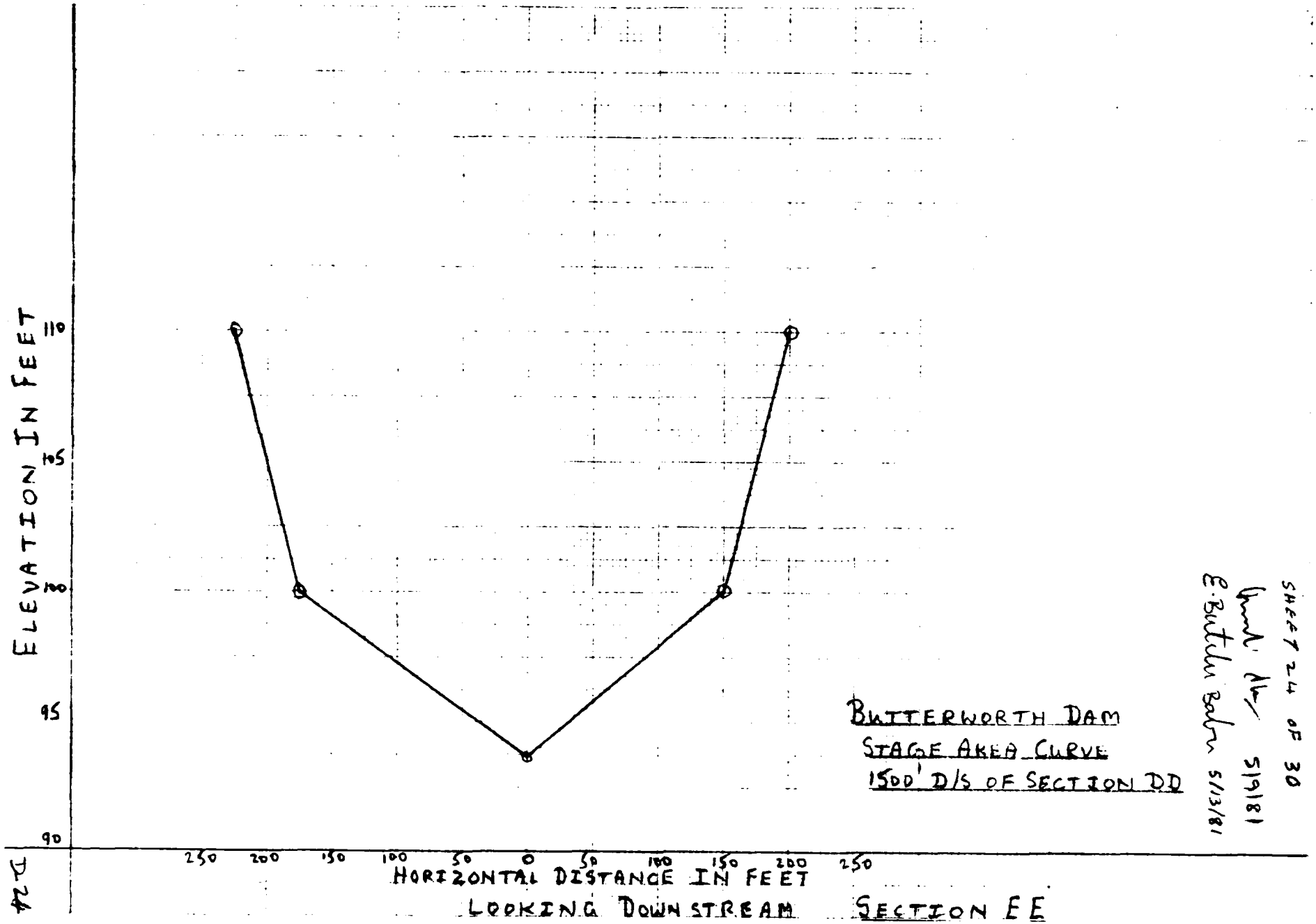
TRIAL $Q_{P_2} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 3940\left(1 - \frac{33.6}{113}\right) \simeq 2770$ CFS
FOR 2770 CFS. ELVN = 99.2 AND AREA 780 SQ. FT

$\therefore V_2 = \frac{1500 \times 780}{43,560} \simeq 26$ Ac. FT

RECOMPUTING $Q_{P_2} = 3,940\left(1 - \frac{\frac{33.6+26}{2}}{113}\right) = 2,900$ CFS
FLOOD STAGE = 99.3 NGVD
DEPTH OF FLOOD WATER AT SECTION EE = 99.3 − 93.7 = 5.6 FT
VELOCITY AT SECTION EE = 2,900 / 808 = 3.6 FPS
PEAK OUTFLOW Q_{P_2} = 2900 CFS

CAPACITY OF THE BRIDGE ON TUTTLE AVENUE IS ESTIMATED TO BE 1800 CFS. THUS, THE BRIDGE DOES NOT HAVE ADEQUATE CAPACITY TO PASS THIS PEAK OUTFLOW OF 2900 CFS.



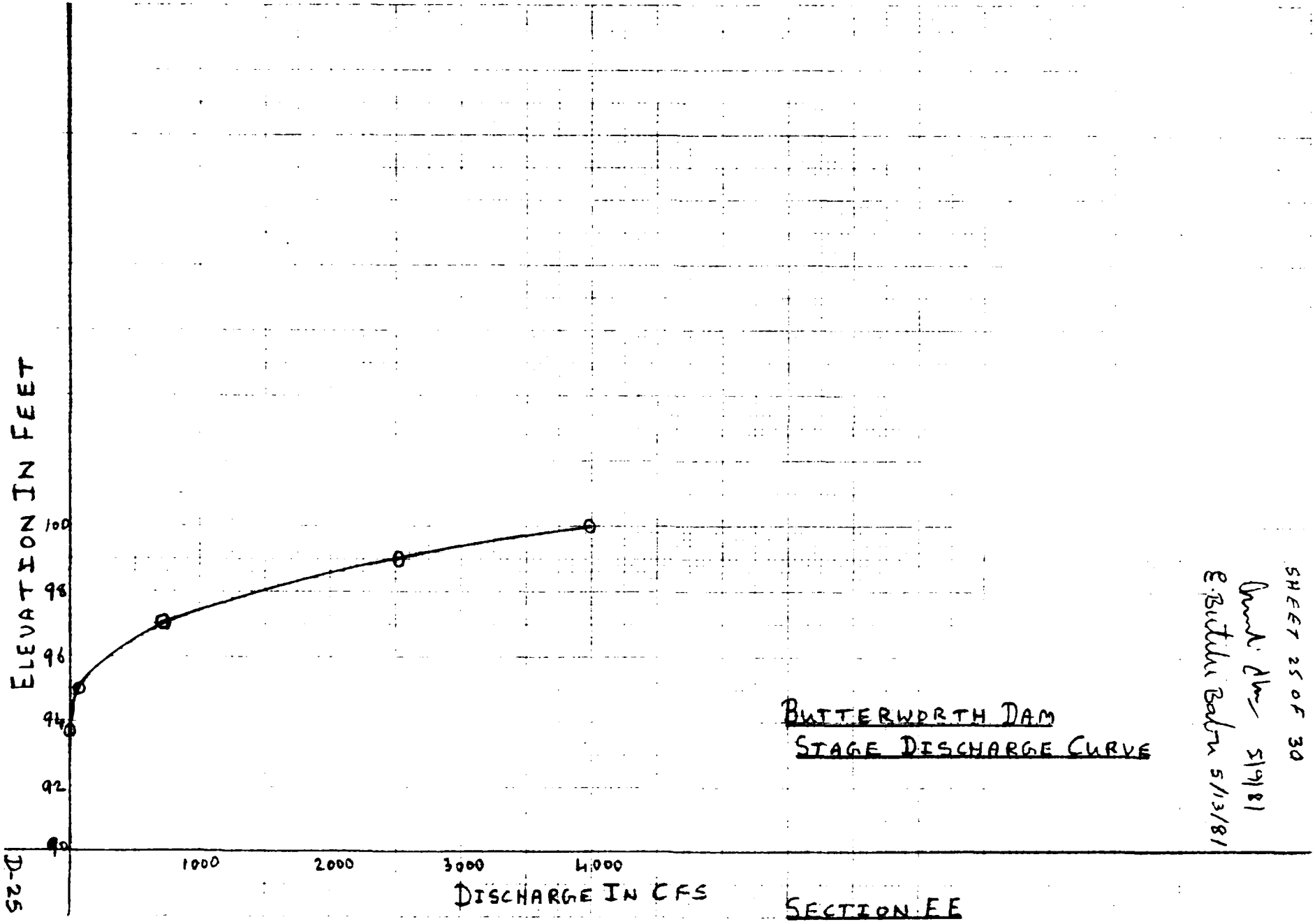


BUTTERWORTH DAM
STAGE AREA CURVE
1500' D/S OF SECTION DD

SECTION EE

SHEET 24 OF 30
5/19/81
E. Butler Baker 5/13/81

D-24



BUTTERWORTH DAM
STAGE DISCHARGE CURVE

SECTION EE

SHEET 25 OF 30
Chuck Chu 5/19/81
E. Butler Baker 5/13/81

SELECT SECTION FF 1500' D/S OF SECTION EE (ABOVE AXLE SHOP POND NEAR WHITNEY AVE)

$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$ Where $n = 0.045$ ASSUMED

$S = 0.0025$ ESTIMATED FROM USGS MAP

EL	A Sq FT	P	R	$R^{2/3}$	Q CFS
91	0	—	—	—	0
93	85	85	1	1	155
95	336	168	2	1.6	975
97	750	250	3	2.08	2825
98	1029	294	3.5	2.3	4285

STAGE AREA AND STAGE DISCHARGE CURVES ARE PLOTTED

FOR $QP_1 = 2,900$ CFS, ELVN = 97 AND AREA = 750 SQ·FT.

VOLUME OF REACH $V_1 = \frac{1500 \times 750}{43,560} = 25.5$ AC·FT

TRIAL $QP_2 = QP_1\left(1 - \frac{V_1}{S}\right) = 2,900\left(1 - \frac{25.5}{113}\right) = 2245$ CFS

FOR 2245 CFS, ELVN = 96.5 AND AREA = 632 SQ·FT

$\therefore V_2 = \frac{1500 \times 632}{43,560} = 21.5$ AC·FT

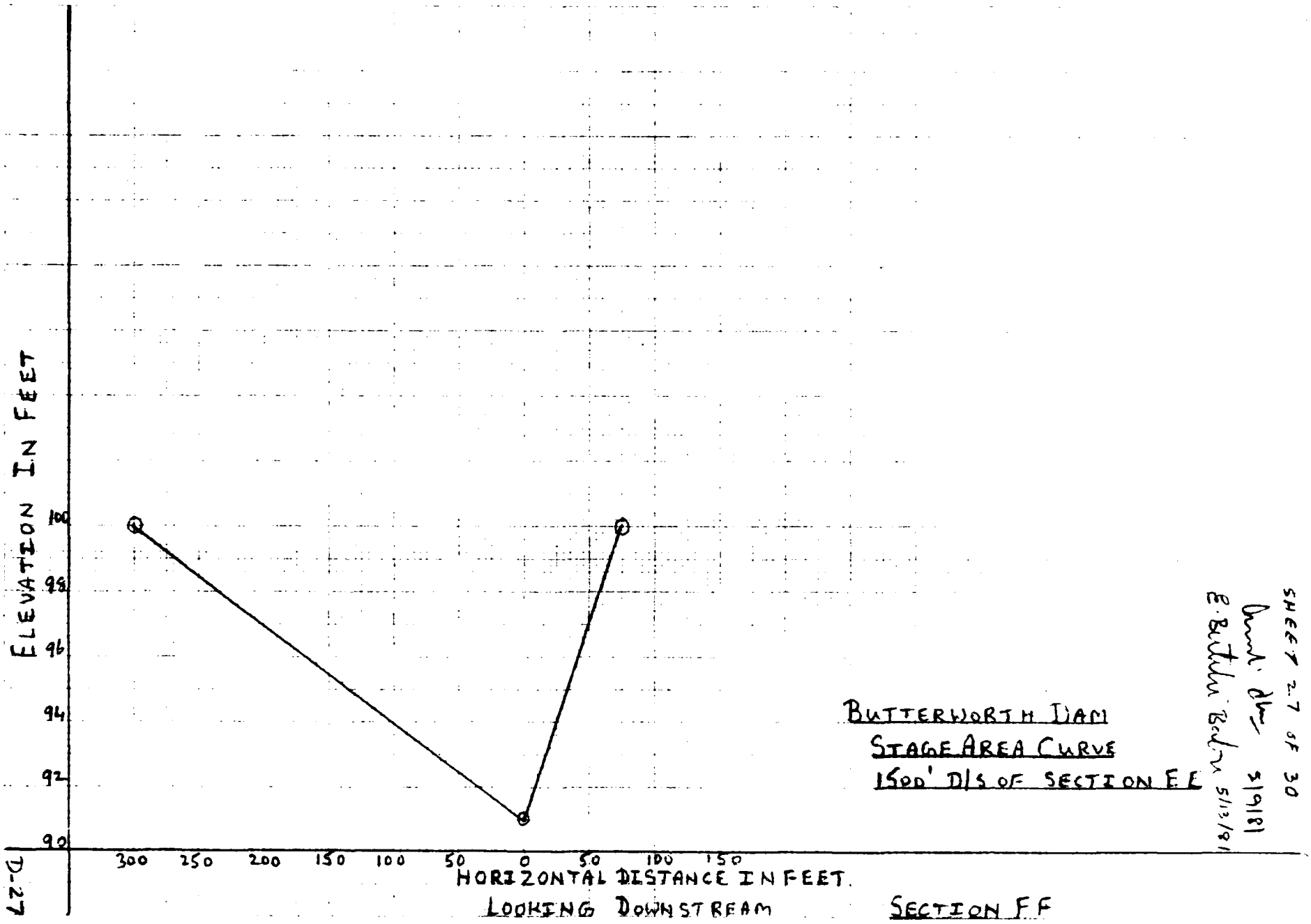
RECOMPUTING $QP_2 = 2,900\left(1 - \frac{25.5 + 21.5}{2}{113}\right) \cong 2300$ CFS

FLOOD STAGE = 96.6 NGVD

DEPTH OF FLOOD WATER AT SECTION FF = 96.6 − 91 = 5.6 FT

VELOCITY AT SECTION FF $= \frac{2,300}{658} = 3.5$ FPS

PEAK OUTFLOW QP_2 = 2300 CFS



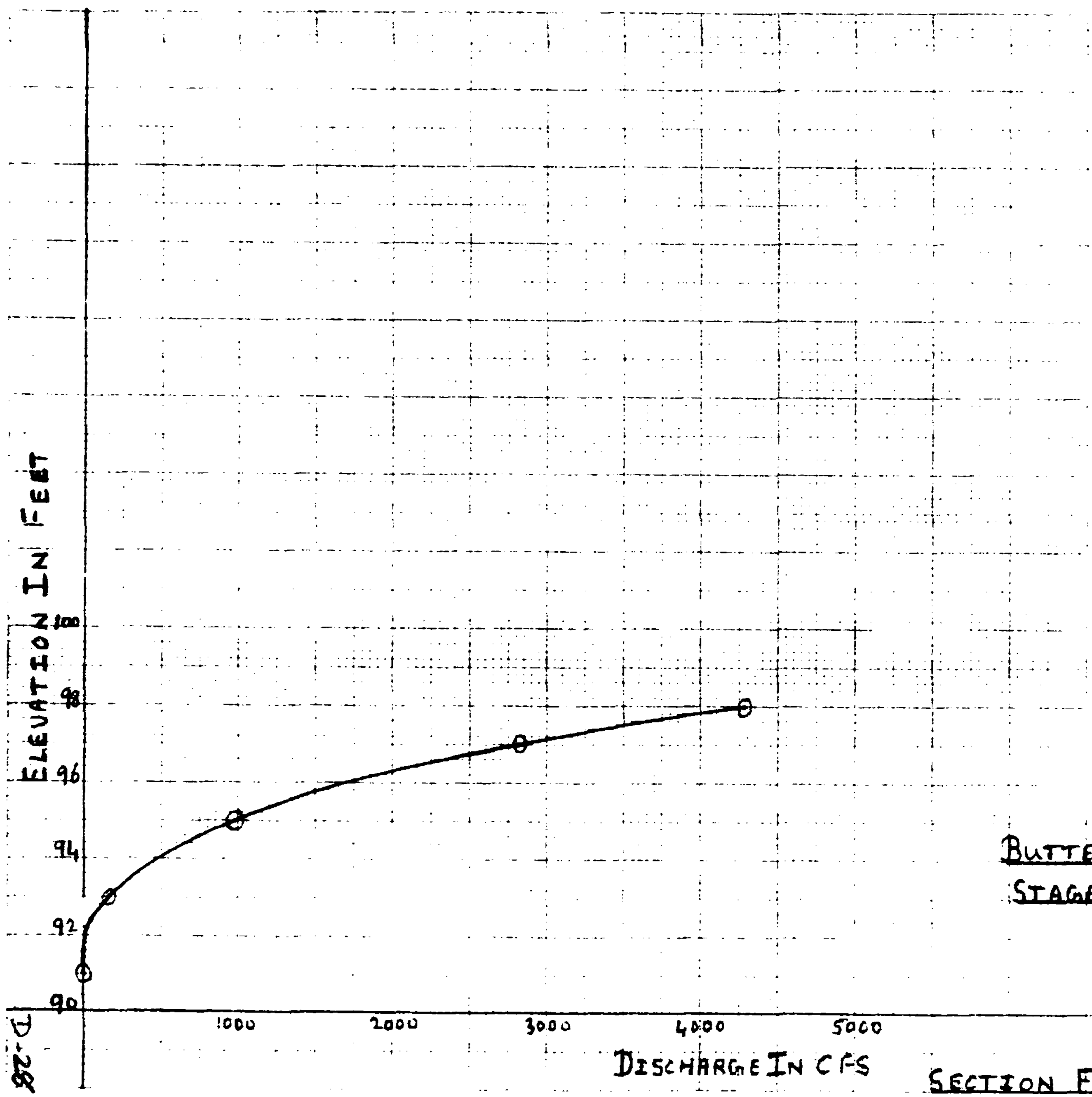
BUTTERWORTH DAM
STAGE AREA CURVE
1500' D/S OF SECTION E E

SECTION F F

SHEET 27 OF 30
Chuck Dam 3/1981
E. Butler Bodine 5/13/81

[illegible signature] 5/9/81
E. Butulu Babu 5/13/81

BUTTERWORTH DAM
STAGE DISCHARGE CURVE



SECTION EF

FAILURE HAZARD POTENTIAL

BASED UPON THE EXISTING INFORMATION, THE LOWEST SECTION OF THE DAM APPEARS TO BE IN THE VICINITY OF THE MAIN SPILLWAY WITH OUTLET DRAIN-PIPE AND HENCE IT IS PRESUMED THAT BREACH OF THE DAM WOULD OCCUR IN THIS VICINITY. THE FAILURE ANALYSIS WAS PERFORMED WITH POOL AT TOP OF DAM (EL. 121.0 NGVD)

SUMMARY OF BREACH ANALYSIS RESULTS:

LOCATION	DISTANCE FROM DAM, FT	PEAK FLOW RATE CFS	FLOOD STAGE NGVD	FLOOD DEPTH, FT	VELOCITY FPS
DAM	0	7300	112.6	6.6	—
AA	520	6210	111.9	6.9	4.6
BB	620	6015	107.9	5.1	4.0
CC	1620	4460	107.8	7.8	3.8
DD	2220	3940	105.3	7.1	4.4
EE	3720	2900	99.3	5.6	3.6
FF	5220	2300	96.6	5.6	3.5

THE RIVER ROAD BRIDGE DOES NOT HAVE THE CAPACITY TO PASS THE PEAK FLOOD FLOW OF 6210 CFS (SECTION AA), WHICH CREATES A BRIDGE FAILURE HAZARD.
FURTHER DOWNSTREAM, SOUTH-EASTERN PORTION OF THE SLEEPING GIANT GOLF COURSE WILL BE SUBJECTED TO INUNDATION BY FLOOD WATERS WITH AN ESTIMATED STAGE OF 105.3. THE GOLF COURSE APPEARS TO BE IN ACTIVE USE AND WOULD EXPERIENCE ECONOMIC LOSS AS WELL AS POSSIBLE LOSS OF A FEW LIVES AS A RESULT OF DAM FAILURE. THE TUTTLE AVE. BRIDGE DOES NOT HAVE ADEQUATE CAPACITY FOR THE 2900 CFS PEAK FLOW.
HENCE, A HAZARD POTENTIAL OF SIGNIFICANT MAGNITUDE IS CONSIDERED LIKELY.

PROJECT NON FEDERAL DAM INSPECTION PROJECT NO. 80-20-10 SH
NEW ENGLAND DIVISION COMPUTED BY
BUTTERWORTH DAM CHECKED BY E. Butler Baker

SUMMARY-HYDRAULIC/HYDROLOGIC COMPUTATIONS

PERFORMANCE AT PEAK FLOOD CONDITIONS

TEST FLOOD	1(
PEAK INFLOW	14(
PEAK OUTFLOW	12(
MAIN SPILL.CAP.TO TOP OF DAM(EL.121 NGVD)	9
MAIN SPILL.CAP.TO TOP OF DAM % OF PEAK OUTFLOW	
MAIN SPILL.CAP.TO PEAK FLOOD ELVN 120.4 NGVD	8
MAIN SPILL.CAP.TO PEAK FLOOD ELVN % OF PEAK OUTFLOW	
EMERGENCY SP.CAP. TO PEAK FLOOD ELVN	3
EMERGENCY SP.CAP. TO PEAK FLOOD EL% OF PEAK OUTFLOW	

PERFORMANCE:

MAXIMUM POOL ELVN	1
MAX. SURCHARGE HEIGHT ABOVE MAIN SP. CREST	
NON-OVERFLOW SECTION OF THE DAM OVERTOPPED	

DOWNSTREAM FAILURE CONDITIONS

PEAK FAILURE OUTFLOW	73(
FLOOD DEPTH IMMEDIATELY D/S FROM DAM	
CONDITIONS AT THE IMPACT AREA: SECTION DD (STREAM BED EL.98.2)	
EST. STAGE BEFORE FAILURE	1(
EST. STAGE AFTER FAILURE WITH 3940 CFS	1(
EST. RAISE IN STAGE AFTER FAILURE ΔY_1	

PRELIMINARY GUIDANCE

FOR ESTIMATING

MAXIMUM PROBABLE DISCHARGES

IN

PHASE I DAM SAFETY

INVESTIGATIONS

New England Division
Corps of Engineers

March 1978

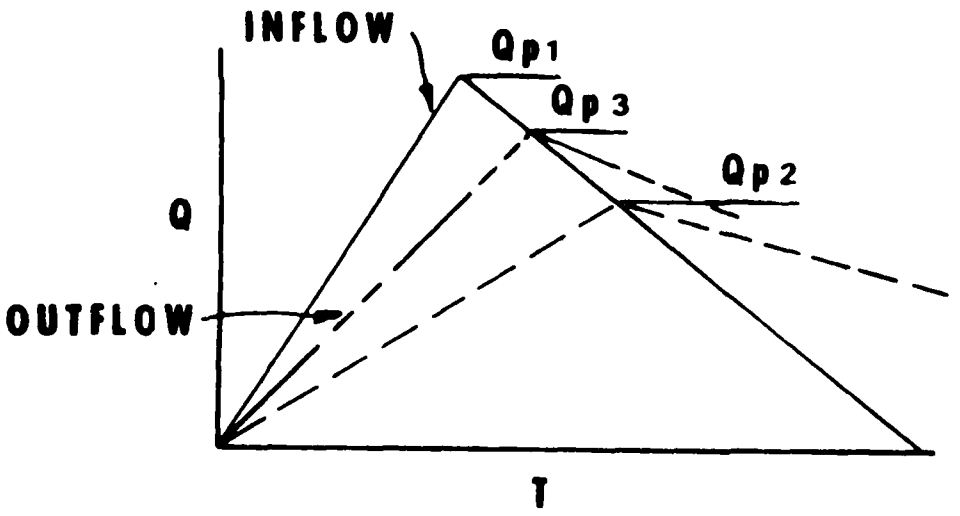
MAXIMJM PROBABLE FLOOD INFLOWS
NED RESERVOIRS

	Project	Q (cfs)	D.A. (sq. mi.)	MPF cfs/sq. mi.
1.	Hall Meadow Brook	26,600	17.2	1,546
2.	East Branch	15,500	9.25	1,675
3.	Thomaston	158,000	97.2	1,625
4.	Northfield Brook	9,000	5.7	1,580
5.	Black Rock	35,000	20.4	1,715
6.	Hancock Brook	20,700	12.0	1,725
7.	Hop Brook	26,400	16.4	1,610
8.	Tully	47,000	50.0	940
9.	Barre Falls	61,000	55.0	1,109
10.	Conant Brook	11,900	7.8	1,525
11.	Knightville	160,000	162.0	987
12.	Littleville	98,000	52.3	1,870
13.	Colebrook River	165,000	118.0	1,400
14.	Mad River	30,000	18.2	1,650
15.	Sucker Brook	6,500	3.43	1,895
16.	Union Village	110,000	126.0	873
17.	North Hartland	199,000	220.0	904
18.	North Springfield	157,000	158.0	994
19.	Ball Mountain	190,000	172.0	1,105
20.	Townshend	228,000	106.0(278 total)	820
21.	Surry Mountain	63,000	100.0	630
22.	Otter Brook	45,000	47.0	957
23.	Birch Hill	88,500	175.0	505
24.	East Brimfield	73,900	67.5	1,095
25.	Westville	38,400	99.5(32 net)	1,200
26.	West Thompson	85,000	173.5(74 net)	1,150
27.	Hodges Village	35,600	31.1	1,145
28.	Buffumville	36,500	26.5	1,377
29.	Mansfield Hollow	125,000	159.0	786
30.	West Hill	26,000	28.0	928
31.	Franklin Falls	210,000	1000.0	210
32.	Blackwater	66,500	128.0	520
33.	Hopkinton	135,000	426.0	316
34.	Everett	68,000	64.0	1,062
35.	MacDowell	36,300	44.0	825

MAXIMUM PROBABLE FLOWS BASED ON TWICE THE STANDARD PROJECT FLOOD (Flat and Coastal Areas)

	River	SPF (cfs)	D.A. (sq. mi.)	MPF (cfs/sq. mi.)
1.	Pawtuxet River	19,000	200	190
2.	Mill River (R.I.)	8,500	34	500
3.	Peters River (R.I.)	3,200	13	490
4.	Kettle Brook	8,000	30	530
5.	Sudbury River.	11,700	86	270
6.	Indian Brook (Hopk.)	1,000	5.9	340
7.	Charles River.	6,000	184	65
8.	Blackstone River.	43,000	416	200
9.	Quinebaug River	55,000	331	330

ESTIMATING EFFECT OF SURCHARGE STORAGE ON MAXIMUM PROBABLE DISCHARGES



STEP 1: Determine Peak Inflow (Qp_1) from Guide Curves.

STEP 2: a. Determine Surcharge Height To Pass "Qp_1".

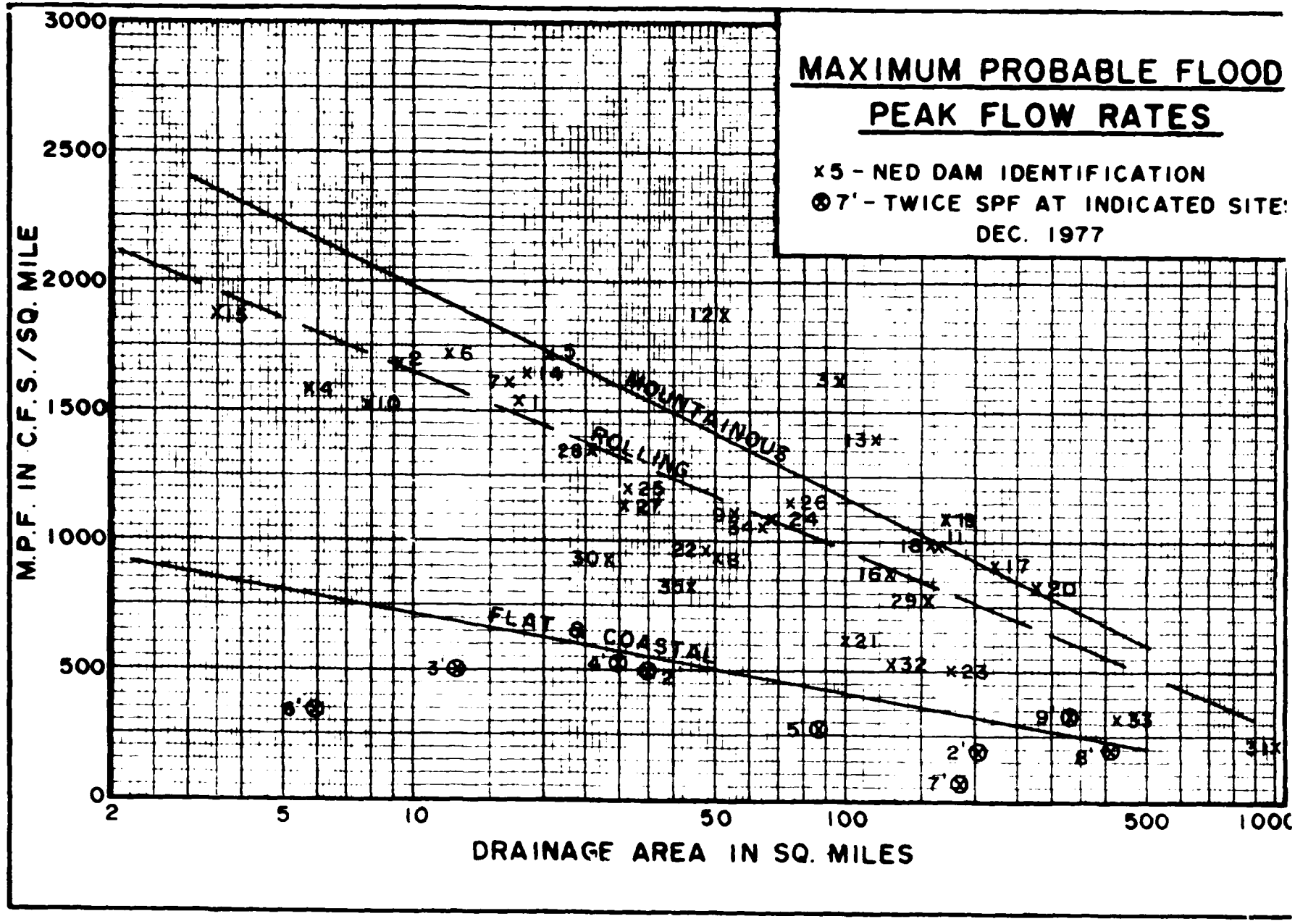
b. Determine Volume of Surcharge ($STOR_1$) In Inches of Runoff.

c. Maximum Probable Flood Runoff In New England equals Approx. 19", Therefore:

$$Qp_2 = Qp_1 \times \left(1 - \frac{STOR_1}{19}\right)$$

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Qp_2"

b. Average "$STOR_1$" and "$STOR_2$" and Determine Average Surcharge and Resulting Peak Outflow "Qp_3".


MAXIMUM PROBABLE FLOOD
PEAK FLOW RATES
x5 - NED DAM IDENTIFICATION
⊗7' - TWICE SPF AT INDICATED SITES
DEC. 1977
M.P.F. IN C.F.S./SQ. MILE
DRAINAGE AREA IN SQ. MILES
3000
2500
2000
1500
1000
500
0
2
5
10
50
100
500
1000
MOUNTAINOUS
ROLLING
FLAT & COASTAL

SURCHARGE STORAGE ROUTING SUPPLEMENT

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Qp_2"

b. Avg "$STOR_1$" and "$STOR_2$" and Compute "Qp_3".

c. If Surcharge Height for Qp_3 and "$STOR_{AVG}$" agree O.K. If Not:

STEP 4: a. Determine Surcharge Height and "$STOR_3$" To Pass "Qp_3"

b. Avg. "Old $STOR_{AVG}$" and "$STOR_3$" and Compute "Qp_4"

c. Surcharge Height for Qp_4 and "New $STOR_{Avg}$" should Agree closely

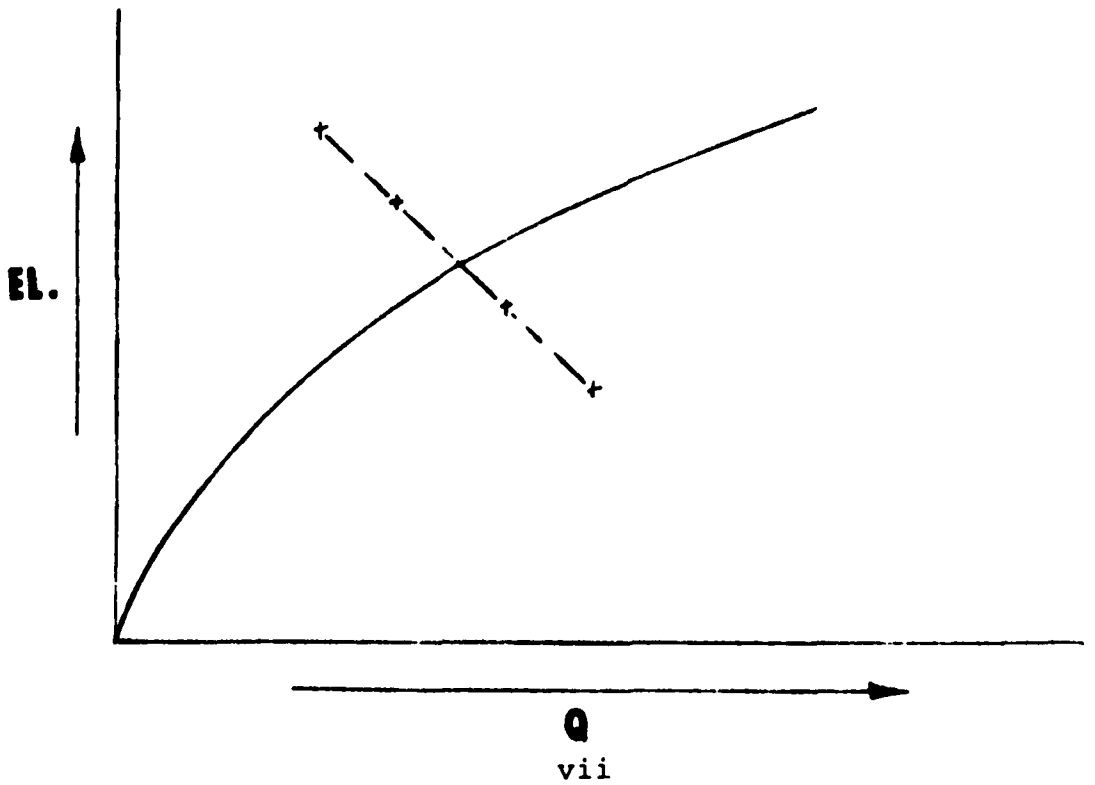
SURCHARGE STORAGE ROUTING ALTERNATE

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{STOR}{19}\right)$$

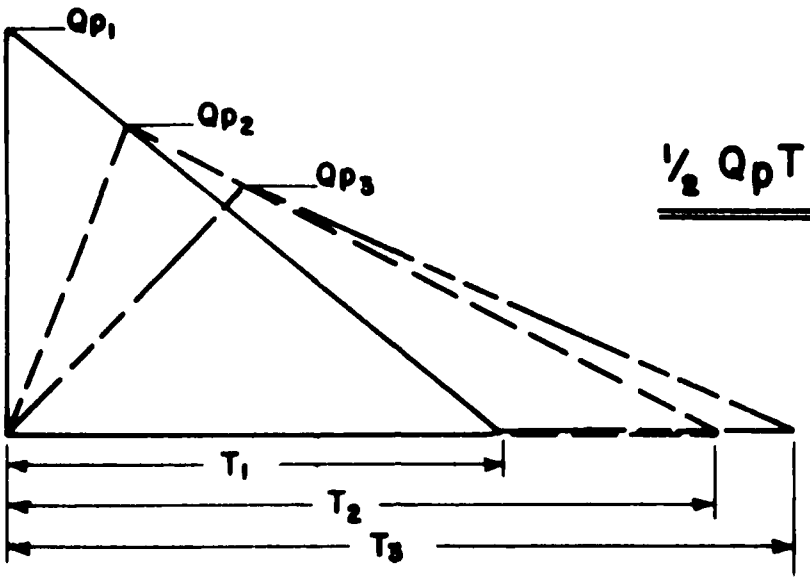
$$Q_{p2} = Q_{p1} - Q_{p1}\left(\frac{STOR}{19}\right)$$

FOR KNOWN Q_{p1} AND 19" R.O.

Q_{p2} STOR EL.



"RULE OF THUMB" GUIDANCE FOR ESTIMATING DOWNSTREAM DAM FAILURE HYDROGRAPHS



$\frac{1}{2} Q_p T = 12 S$

STEP 1: DETERMINE OR ESTIMATE RESERVOIR STORAGE (S) IN AC-FT AT TIME OF FAILURE.

STEP 2: DETERMINE PEAK FAILURE OUTFLOW (Q_{p1}).

$$Qp_1 = \frac{8}{27} W_b \sqrt{g} Y_o^{\frac{3}{2}}$$

W_b = BREACH WIDTH - SUGGEST VALUE NOT GREATER THAN 40% OF DAM LENGTH ACROSS RIVER AT MID HEIGHT.

Y_o = TOTAL HEIGHT FROM RIVER BED TO POOL LEVEL AT FAILURE.

STEP 3: USING USGS TOPO OR OTHER DATA, DEVELOP REPRESENTATIVE STAGE-DISCHARGE RATING FOR SELECTED DOWNSTREAM RIVER REACH.

STEP 4: ESTIMATE REACH OUTFLOW (Q_{p2}) USING FOLLOWING ITERATION.

A. APPLY Q_{p1} TO STAGE RATING, DETERMINE STAGE AND ACCOPMANYING VOLUME (V_1) IN REACH IN AC-FT. (NOTE: IF V_1 EXCEEDS 1/2 OF S, SELECT SHORTER REACH.)

B. DETERMINE TRIAL Q_{p2}.

$$Qp_2(\text{TRIAL}) = Qp_1 \left(1 - \frac{V_1}{S}\right)$$

C. COMPUTE V_2 USING Q_{p2} (TRIAL).

D. AVERAGE V_1 AND V_2 AND COMPUTE Q_{p2}.

$$Qp_2 = Qp_1 \left(1 - \frac{V_{ave}}{S}\right)$$

STEP 5: FOR SUCCEEDING REACHES REPEAT STEPS 3 AND 4.

APRIL 1978

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME

END

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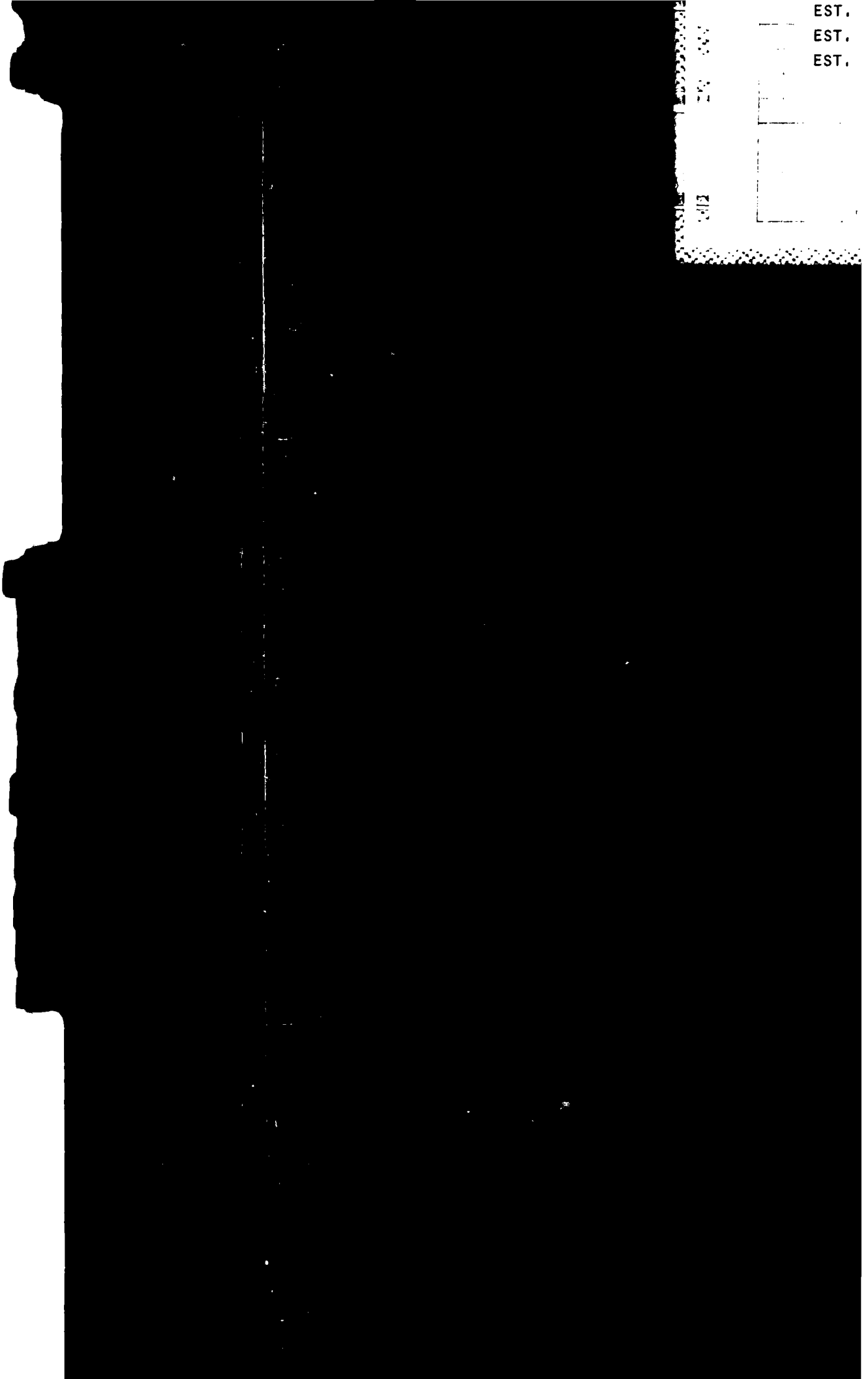
EST.
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